THE

INDICATIONS OF THE CREATOR:

OR

THE NATURAL EVIDENCES

OF

FINAL CAUSE.

BY

GEORGE TAYLOR

Besides the pleasure derived from acquired knowledge, there lurks in the mind of man, and tinged with a shade of sadness, an unsatisfied longing for something beyond the present—a striving towards regions yet unknown and unopened.—HUMBOLDT.

THIRD EDITION.

NEW YORK:
CHARLES SCRIBNER, 124 GRAND STREET.
1859.

TO

MY FATHER,

WHOSE KINDNESS SUPPORTED, AND WHOSE COUNSELS DIRECTED ME, IN MY YOUTH; AND BY WHOSE ADVICE THE LEISURE HOURS OF LIFE HAVE BEEN DEVOTED TO SELF-IMPROVEMENT; THESE LEAVES, GATHERED AT DIFFERENT TIMES, AND UNDER VARIOUS CIRCUMSTANCES, ARE AFFECTIONATELY INSCRIBED.

PREFACE.

We have been induced to submit the following pages to the public, by the favorable reception which was given to a part of the contents when published in another form.

Much has been written on the same important subjects; but generally the sciences have been treated separately. We have here made an effort to group them together, and to show their relations and adaptations, and their necessary dependence on each other, believing this to be the best way to secure the object contemplated.

In the collection of our facts from the domain of science, the most reliable Authors have been consulted, and many quotations from such have been introduced. And in all cases where it was possible, the name of the authority has been given.

We have written during the leisure hours of a professional life; hoping to enlarge our own view of the material universe and of its Author; and we now publish what was thus written, with the hope that others may be induced to devote some portion of their time to the contemplation of the mysterious potencies which surround them, and of the Infinite Power by which those potencies are directed and controlled.

July 28, 1851

CONTENTS.

PART I.

NEBULAR HYPOTHESIS

I.

II.

PART II.

ASTRONOMY.

I.

II.

III.

PART III.

GEOLOGY.

I.

II.

III.

IV.

V.

VI.

VII.

VIII.

PART IV.

COMPARATIVE PHYSIOLOGY

I.

II.

III.

PART V.

PHYSICAL GEOGRAPHY.

I.

II.

III.

INTRODUCTION.

THERE was a time when this Planet, now so crowded with life and beauty, existed in the contemplation only of the INFINITE MIND. The Orbit in which our pathway lies, like the immeasurable fields of space beyond the existing stellar and planetary families, had no visible tenant. No planet answered the primeval orbs with its language of light, or told of its unceasing activity by continued changes and varied appearances. But, even then, the mighty mechanism was perfect in the mind of the ETERNAL. Nothing was wanting to fill up the varied parts with well adapted forms and unceasing life, but His ALMIGHTY mandate.

There is no record to tell how long this state of things existed. We know only that CREATIVE WISDOM thought it best to introduce this sphere into the family; and that in doing so, it was adapted to

the varied life it was destined to support. The light was divided from the darkness, and the waters gathered together so that the dry land appeared. Continents were created, mountains elevated, the surface of the earth enlivened by streams, and the waters collected into deep seas, after which, the elements were filled with animal and vegetable life. Thus the creation advanced, until it was prepared for the introduction of man, its intellectual sovereign, who was honored with the image of the Father.

Of this Creation, a brief history only has been given to mankind; and in it, the time occupied is divided into periods apparently too short to agree with the natural phenomena. The first impression made by the sacred record, was, that the whole Creation was accomplished in a few of our modern days; while the geological formations induced the belief that unnumbered ages of active preparation preceded the introduction of man. These early opinions necessarily arrayed the friends of the two records against each other. Geologists denied the correctness of revelation, and the friends of the sacred history ridiculed geology. This conflict of opinions resulted unavoidably from the imperfection of human knowledge. One of the records was too literally interpreted, while the bold characters of the other were but partially understood.

How long these difficulties would have continued to disturb society, had not other sciences contributed to widen the breach, it is impossible to say. But it is quite certain that the opinion of Geoffrey St. Hillaire, regarding the transmutation of species, followed up and enforced by Lamarck; and the discovery of bodies in the far-off regions of space, supposed to be "Nebulous" in their character, were indispensably necessary to perfect the system of infidelity which fastened itself on the sciences. It grew gradually, not upon any single fact, but upon a multitude of errors which sprung up in the different departments of human knowledge, and which pointed with remarkable harmony to the same conclusions.

The cosmogony of our globe has been a fruitful subject for speculation ever since the days of Pythagoras. After that philosopher had enriched his mind with the Egyptian and Persian lore, he returned to his own country with a system of the world which is remarkable for its singular mixture of truth and error. It met the concurrence, however, of Aristotle; and to judge from passages in Phædo and Theaetetus, Plato must have entertained similar views. Pythagoras contended that nothing retained the same image for any length of time, but that they did not perish, as they only changed their forms; that all things were undergoing a constant change;

the earth and sea, and all that they contained. "Solid land," he said, "has been converted into sea, and the sea has been changed into land." Aristotle, following up the same idea, says; "The distribution of land and sea in particular regions, does not endure throughout all time, but it becomes sea in those parts where it was land, and again it becomes land where it was sea. . . . As time never fails, and the universe is eternal, neither the Tanais nor the Nile can have flowed for ever. The places where they rise were once dry, and there is a limit to their operations; but there is none to time." Other ancient philosophers advocated this system; while another school promulgated different views. Thus speculation followed speculation, and theory succeeded theory, until the latter part of the eighteenth century, when the whole artillery of learning and science, in certain localities, was turned against the Christian religion. Many causes operated to bring this about.

Among the first questions for the philosopher to answer, and the theologian to combat, were those connected with the deluge. These necessarily led to those involved in the history of the Creation of the world, many of which are still unsettled. The Naturalist found petrified shells scattered over the surface of the earth, irregularly, without any regard

to locality. The mountain-top contained as many as the valley below. It appeared quite certain to many that these shells were of marine origin, while others believed that they were sports of nature. But supposing them to be true shells, it was difficult to account for their location. This the friends of the Mosaic record explained by the deluge, while the geologist thought the mountains had been raised by some internal force, after the shells had been deposited, and that they necessarily carried their fossil freight up with them. But this suggested another difficulty; by what force were these terrestrial elevations effected? And here was another division of opinion. A few savans attributed their elevation to earthquakes; while the greater part thought the inequalities of the earth's surface resulted from the influence of the oceanic element.

Palissy opened the debate on these questions in the latter part of the sixteenth century. He contended that the fossil shells were of marine origin, and that they had been scattered over the surface of the earth, during the changes which took place from time to time, in the ocean. This idea was received with great bitterness by the theologians of that day. They felt the importance of sustaining the Scriptural account of the deluge; and as they considered the location of these shells important corroborative testi-

mony, any, and all other explanations met their unqualified displeasure. It would be difficult, if not useless, to trace all these questions through the multiplied phases and forms which they were forced to assume. Almost every philosopher had his own theory, and with few exceptions, these theories were opposed to the Mosaic cosmogony.

Thus these questions remained without any particular interference or restraint, until Buffon, who was at the head of one of the schools, published his views. This was done with such boldness, that the Sorbonne of Paris felt it necessary to interpose their authority. He said in his Theory of the Earth, that "The waters of the sea have produced the mountains and valleys of the land," and that "the waters of the heavens, reducing all to a level, will at last deliver the whole land over to the sea, and the sea successively prevailing over the land, will leave dry new continents like those which we inhabit." This was not more objectionable than the theory advanced by Pythagoras and Aristotle, and others contemporary with Buffon. He, however, was compelled to renounce his opinions publicly, by that distinguished Faculty of Theology, distinguished more for that act of persecution than anything else.

But the course pursued by the Sorbonne did not secure the object they contemplated. The theory

was advocated on the continent with great ability; and finally met an able advocate on the other side of the channel. These debates prepared the public mind, notwithstanding the action of the Sorbonne, for the Huttonian theory; which, although denounced as atheistical at the time, was warmly received by many of the most active and influential members of the learned fraternity. Hutton contended that the ruins of an older world were visible in the composition of this, and that there were no traces of a beginning, and no prospect of an end; that there had been at least three distinct periods of animal existence before the introduction of man; and that all the changes of the globe had been effected by the agency of causes which were then acting gradually upon it.

These questions, with others necessarily connected with them, excited the deepest interest, and the most searching investigation. The surface of the earth was explored, and its deepest caverns penetrated. Every visible witness in the wide domain of nature was interrogated. The living species were collected and arranged, and the interior of the earth was forced to yield the testimony of its buried tenantry.

At this time, when the excitement had attained its highest point, Lamarck, a celebrated naturalist, suggested his hypothesis of organic progress or

development. He found, in trying to arrange the species, that they ran into each other, or that the difference between them was so small, that it was almost impossible to tell where one ended and another began. It appeared also, that the greatest changes were effected by cultivation, domestication, &c. He believed that plants and animals were frequently surrounded by circumstances which either imposed restraint or stimulated unusual efforts, and by which their character and physical organization might be changed. He contended that we had an example of this change in wheat, as a similar plant could not be found as a native of any country. These changes are also common in domestic animals, many of which are found only in their domestic condition. Other animals were changed according to this theory, by circumstances which imposed a necessary alteration of some of their organs. A bird, for example, driven to the water for food, would stretch out its claws to enable it to swim, and that in these efforts it would finally become web-footed.

The successors of this distinguished Savan carried the idea still farther. They contended that animals and plants, not only advanced in type and character during successive generations, but that there are natural forces capable of producing all the varied organisms, and that the *laws* by which the existing

species were created, are still operating to a certain extent. Thus, they assigned to the operation of general laws, what Lamarck attributed to the influence of particular causes. In doing so, they disparaged the influence and action of the GREAT CREATOR, by transferring HIS chief prerogatives to mere physical forces, and by reducing HIM to the position of a silent observer of the Infinite potencies which it is admitted, HE originally created, but over which HE exercises no control.

Geologists reported a succession of organic remains in the strata of the earth's crust, and also that the lower or earlier denizens were of an inferior order, and that the character and organization improved as you ascended in the geological formations. This led them to adopt the idea of a regular advance from the lower to the higher orders and departments of the vegetable and animal kingdoms, beginning at the lowest order and extending to the human mind, that superior faculty by which man is enabled to arrange and survey the multiplied parts of the material universe. Thus, while Lamarck and his successors advocated the transmutation of species, and their gradual development and improvement, the geologist insisted that the records of past generations as written on stone by the extinct species themselves, proved the theory to be true.

This was the position of things at the beginning of the present century, when a new and important element was added by another department of human knowledge. Geology and physiology had united their testimony, while up to that period Astronomy had served rather as a check upon its sister sciences; but it was now destined to take a different position. Simon Marius, Huygens, and Messier, had previously discovered dim and mysterious bodies, faintly shining out amid the darkness of the far-off regions, but the imperfection of their instruments prevented them from distinguishing their true character. It was suggested that they were composed of stars, but this was not generally believed; many thought they were merely self-luminous clouds; and this opinion seemed to gather strength from their inability to resolve these luminous masses into distinct stellar bodies.

These mysterious bodies were now brought under the increased instrumental power of Sir William Herschel's improved telescopes; but he was not much more successful in detecting their true character, than his predecessors had been. It is true, he succeeded in arranging them in classes; some of which he called resolvable nebulæ, or nebulæ which gave signs that they might be resolved into stars by

increased instrumental power, and true nebulæ, or such as he believed to be irresolvable. He thought he had been able to apply a certain and reliable test to them, and that such undoubtedly was their character. Thus, while the labors of Sir William resulted in the discovery of the true nature of the resolvable class, they contributed to confirm the belief in a real nebulosity, and led finally to the theory of Laplace.

While Sir William was engaged in observing these nebulous appearances, he discovered certain bodies which appeared to represent planets and stars in the different periods of their growth; some half-formed, and others but one degree removed from the nebulæ, which was considered the rudimental material. Thus he was forced to the conclusion that these bodies were in the process of formation, under the direction of some natural force, and that these phenomena represented the members of one family; as infants, half-grown children, and adults. This led astronomers to adopt the Huttonian principle; for, if all the stages of growth exist, then the agencies by which they are produced must be at work now the same as they were in the beginning. And as these phenomena appeared to be developing themselves gradually without the aid of any supernatural

cause, they must depend upon and result from laws within the system itself. By this course of reasoning, the only element wanting in the development theory was supplied by astronomers. The materials were now ready for a complete system of the world, and ingenious infidelity was not long in its arrangement.

It was supposed that all the heavenly bodies were elaborated out of this nebulous material by the forces of attraction and radiation. That in the beginning this attenuated fire-cloud filled all space; and that by some cause unknown, and at some period equally uncertain, a nucleus was formed, to which this nebulous matter was drawn by the force of attraction, and around which it commenced its revolutions. Thus the sun, the great central body of our system, began its career of usefulness. After a certain length of time, the first planet was thrown off from the great primary; and then again another; and these in turn threw off their satellites. And thus the process was continued until this globe was swung into its orbit. A rough cast, perhaps, but nevertheless subject to certain laws which were designed to fit it for the various forms and grades of life to which accident might introduce it. These changes were all effected according to this theory, without the aid of any other agency than those of

attraction and radiation. There was no superior CAUSE of CAUSES—no POWER behind the clouds, moving the machinery, and ordering the results.

This globe having taken its place under such circumstances, is at first covered with water, and is, therefore, unfit for anything but marine vegetable life, and the lowest order of mollusks. These were forced into existence by some electric or chemical agency, as yet imperfectly understood, but when once in existence, they became the Adams of the earth, and the parents of a numerous and infinitely varied progeny. Thus the Nebular hypothesis was interwoven with the Development theory, and a complete system of the world constructed out of the two.

It will not be forgotten that these theories were perfected in times well adapted to the infidelity which they taught,——when the ministerial corps, for some reason either within itself, or without its sacred precincts, had become unpopular—when Paine and kindred writers were encouraged by the people, and supported by crowned heads; and when, if an author desired to distinguish himself and enrich his family, he had only to minister to the infidel age in which he lived. The seed, however, had been sown, and in many instances by minds having little or no sympathy with those who cultivated it for such mis-

chievous purposes, and it became the duty of the philosopher and the Christian, to correct the errors and refute the arguments of an unbelieving age; and to erect a more perfect and holy temple out of the sacred truths of science.

The astronomical part of this task could not be performed without an increase of instrumental power. Sir William Herschel had exhausted the greatest power of his best telescopes in arriving at the conclusions heretofore referred to; and nothing more was expected from that source until the ingenious artisan succeeded in arming the philosopher with a longer vision. To this important end the efforts of a better age were directed. In the geological and physiological divisions, time and labor only were wanting. The great book of nature had been but partially opened. Its mightiest volumes and profoundest secrets were still locked up in the rock formations of the earth. These were to be broken open, and their widely-scattered leaves collected and arranged.

The records of the Silurian system had to be gathered up by Sir Roderick Murchison, and filed away in the mighty archives of science, while the leaves of Stromness, and the plates of the Old Red Sandstone, were to be deposited by the indefatigable Hugh Miller. The reptilian fossil history of the

Carboniferous era had to be written out by Von Meyer, Von Dechen, Dr. King, Isaac Lea, and Prof. Rogers; and that of the Footprints of the New Red Sandstone, by the industrious Hitchcock; and finally, the discoveries of all these distinguished geologists had to be arranged and philosophically treated by the accomplished Lyell, before the geological part of this important work was finished.

It is our present object to trace the progress of these discoveries in the different sciences, and to ascertain, if possible, how far they deny the theories referred to, and to what extent they go, in proving the existence and ever-active presence and goodness of a Great Intelligent First Cause. In doing this we have been led to notice the agreement and adaptation of the infinitely varied parts of the universe, and how each part is inseparably interwoven with every other; and how all work together as some mighty piece of mechanism, in which nothing is wanting, neither can anything be taken away.

If there were no beautiful adaptations—no prearrangement of parts to secure general and particular ends, there would be much more difficulty in refuting the arguments of scientific infidelity. But fortunately for truth and faith, all nature is full of these arrangements. When the friends of these theories are directed to the harmony which everywhere

exists in the universe; they reply, that as there is a natural connection between all things, there is, therefore, a necessary harmony. This was one of the pioneer suppositions in the theory of Laplace. He thought the harmony and just counterbalance of the planetary motions and the general arrangement of the whole system, could be best accounted for by supposing that they had been originally thrown off from a great primary, through the agency of some natural force.

It was not so easy to dispose of the adaptations of the various parts of the creation to each other. It was impossible to deny the necessity of these adaptations, and yet they were not able to point out any physical cause for them. In this way they were compelled to adopt the idea of original design in the universe, and this led them involuntarily towards a belief in the SUPREME INTELLIGENT CAUSE.

By such arguments, the immortal philosopher of Athens was enabled to persuade Aristodemus to believe that man was the masterpiece of some great Artificer, as he carried along with him infinite marks of the love and power of a Creator, whose eye pierceth throughout all nature, and whose ear is open to every sound, extending to all places and all times; and whose bounty and care can know no other bounds than those fixed by his own creation. In this way

the votaries of science were met on their chosen ground; and while nature, to which they appealed, supplied facts from its inexhaustible storehouse of phenomena, more than sufficient to answer the arguments of the unbeliever, the sacred record rose above the dust of the material conflict.

Not indeed above the contradictions or attacks of the infidel philosopher, but superior to them. A contest so unequal could not be maintained for any considerable time, even with the united strength of false science and false men. But the final triumph was delayed by the timidity and compromising spirit of those whose high privilege it was to defend the Mosaic record. They yielded more or less to the ingenuity and boldness of an attack which was conducted with zeal, and apparently sustained by incontrovertible evidence. Had no concessions been made, the question would have ceased to be one of faith, and become one of fact, much sooner.

Every concession made by truth to error and falsehood, contributes to protract the existence and struggle of the latter. The Christian world had abundant evidence of the Divine origin of the sacred record, and of the truth of every material statement, to take its position upon those statements as proved, and to challenge the arguments of their enemies; and to go out of it for confirmation was wholly unnecessary.

The error, therefore, consisted in seeking cumulative evidence from doubtful sources, and in casting the whole issue on the strength of such evidence.

It was fortunate for the final result of this great question, that eternal truths were not made to depend upon the policy of human advocates. Their triumph is certain, however much delayed by error and weakness. So intricate and mysterious is the mighty mechanism of the universe, and of the human mind, that important principles are as frequently stumbled upon, as they are searched out; and yet the CREATOR has arranged the natural agencies so that the full and perfect revelation of every material and important fact is secured. Nor can it be material to HIM who seeth and knoweth all things, whether that revelation is made amidst the thunders of Sinai, and written on stone, or whether it is made in the Secret Chambers of nature; in the delicate shades of some unnoticed flower, or the feeble instinct of some despised insect. With HIM all things are the same; every organism has a voice, and every voice is speaking of the CREATOR. As the human body is to the soul of man, so is the universe to the INFINITE and ETERNAL; and every part is but a different manifestation of the SPIRIT that sustains the whole. Out of HIS great Being all existence sprang, and each mysterious element is an organ for the expression of HIS will.

Science has accomplished much in distinguishing the various forces, and in detecting their connection with, and their influences on, each other; and in doing so it has benefited the human family, by enabling man to apply the natural agencies and forces to his own purposes. It has also ennobled him by giving him a clearer conception of the Power and Goodness of the CREATOR. And thus Science, like all else, has finally contributed to strengthen the Christian's faith, and confirm his hope. As the innumerable inland streams roll steadily on to the deep ocean which awaits them, so all things move on to their INFINITE SOURCE and end.

PART I.

NEBULAR HYPOTHESIS.

I.

As early as the year 1612, the Nebula in Andromeda was described by Simon Marius; but, from the works of Ismael Bouillaud, a writer of the seventeenth century, it appears that this nebula was discovered much earlier than that period. It is probable, says a distinguished astronomer, that it was recognized at least six hundred years before the invention of the telescope. It excited much attention at the time, and has since become one of the most interesting nebulous bodies. Another remarkable Nebula, the one in the Sword of Orion, was discovered and described by Huygens, in 1657. This new discovery contributed to increase the interest and curiosity which its elder sister had excited. It was reserved, however, for Messier, an astronomer of the eighteenth century, to extend the catalogue

of these mysterious bodies, and to lay the foundation for speculations of a most exciting character; which, while they threatened to unsettle established theories and cherished beliefs, have greatly increased our obligations to the science itself, and have led to those glorious achievements of the mind, which have immortalized individuals, and now contribute to dignify and ennoble mankind.

While this distinguished astronomer was engaged in observing comets, to which he devoted much of his time, he discovered one hundred and three objects, or Nebulous Islands, of a light, hazy appearance, irregularly scattered through space. Under moderate telescopic power, these objects appeared as self-luminous islands of vapor; but, when examined with refractors of larger aperture and greater focal length, it was ascertained that many of them consisted entirely of stars, so closely crowded together, that their light blended in a single blaze at the centre. A few of these bodies, however, were not so easily disposed of; among which, the nebulæ in Andromeda and Orion are the principal ones: they defied the space-penetrating power of the finest instruments, and remained, until recently, wholly irresolvable.

The great variety of forms, and the difference in the appearance of these bodies, excited the curiosity,

and engaged the time and attention of successive astronomers for nearly two centuries; but they were made the objects of more particular observation by Sir Willian Herschel, to whom the world is so largely indebted. After much laborious observation, he was enabled, in 1802, to present to the Royal Society a catalogue of two thousand newly-discovered nebulæ, which he had arranged in appropriate classes. These bodies were as irregular in their figures as they were in their distribution. "They are of all degrees of eccentricity," says Sir John Herschel, "from moderately oval forms to ellipses so elongated as to be almost linear." They varied in their appearance from that which seemed to be the irregular aggregation of self-luminous vapor, or 'star-dust,' to the oval island, in which the outlines of stellar bodies were clearly distinguishable.

In Sir William's catalogue, these bodies were divided into globular and irregular clusters; resolvable nebulæ, or such as he believed would yield to increased optical power; nebulæ proper, in which there was no appearance of stars; planetary nebulæ, and nebulous stars. In some instances, the nebulæ presented the appearance of a faint luminous atmosphere, of a circular form, and of large extent, surrounding a star of considerable brilliancy. These

were considered, in the speculations which followed the discoveries, and to which we will soon invite the reader's attention, the oldest, or advanced stages of the nebulous matter, and were called stars with burs; because their light appeared to increase from the borders to the centre. It was soon ascertained that the globular or oval forms yielded readily to increased optical power; and that their appearance was the effect of their great distance from us. The irregular or elliptical clusters were less condensed at the centre; and although some of them, as the one in the girdle of Andromeda, could be seen with the unaided eye, they steadily maintained their nebulous appearance. It was thought, however, that they changed their appearance from time to time; but this was owing to the imperfect sketches taken of them, and the difference in the space-penetrating power of the telescopes used at the various periods.

It was these remarkable and distant bodies, appearing more or less distinct according to their varying distances, which led Sir William Herschel to speculate on the gradual subsidence and condensation of the gaseous or elementary sidereal matter, which, it was thought, was dispersed through the regions of space. "Assuming that in the progress of this subsidence, local centres of condensation, subordinate to the gradual tendency, would not be want-

ing, he conceived that in this way solid nuclei might arise, whose local gravitation still farther condensing, and so absorbing the nebulous matter, each in its immediate neighborhood might ultimately become stars, and the whole nebula finally take on the state of a cluster of stars. Among the multitude of nebulæ revealed by his telescopes, every stage of this process might be considered as displayed to our eyes, and in every modification of form to which the general principle might be conceived to apply. The more or less advanced stages of a nebula toward its aggregation into discrete stars, and these stars themselves towards a denser nucleus, would thus be in some sort indications of age."

The lowest orders or rudimental nebulæ were variable, both in their figures and degrees of brightness. These, it was thought, represented the first stage of aggregation. The more advanced were distinguished from stars by the faint light only by which they were surrounded. These phenomena produced a profound sensation on the mind of the elder Herschel. He, however, felt fully persuaded that these bodies, or a large proportion of them, were simply congeries of stars, so far removed from us as to blend their light, and thus present their nebulous appearance. But they aroused his active and vigilant mind, and prompted him to continue his observations, that he

might become more intimately acquainted with these mysterious strangers. He labored to apply some more certain and reliable test to them, and was gratified, as he supposed, in this desire. While sweeping the heavens with his telescope, he discovered stars shining, or appearing to shine, through floating clouds of this highly attenuated matter. These he believed were ' stars enveloped in circular halos,' and afforded him an opportunity to contrast the true star with the nebulous matter surrounding it. It is difficult to imagine the anxiety and interest which agitated the mind of that great man, at this period of his glorious career. An opportunity to prove or disprove the suspicions which had perplexed his mind so long, now presented itself; and, believing the result of his observations to be of the greatest importance, he must have undertaken the task with feelings of the most trying character. We will give the history of that observation in his own language: "In the first place," he says, "if the nebulosity consist of stars that are very remote, which appear nebulous on account of the small angles their mutual distance subtends to the eye, whereby they will not only, as it were, run into one another, but also appear extremely faint and diluted; then, what must be the enormous size of the central point, which outshines all the rest in so superlative

a degree as to admit of no comparison! In the next place, if the star be no bigger than common, how very small and compressed must be those other luminous points, that are the occasion of the nebulosity which surrounds the central one! As by the former supposition the luminous central point must far exceed the standard of what we call a star, so, in the latter, that shining matter about the centre will be much too small to come under this denomination: we therefore either have a central body which is not a star, or have a star which is involved in a shining fluid of a nature totally unknown to us. I can adopt no other sentiment than the latter, since the probability is certainly not for the existence of so enormous a body as would be required to shine like a star of the eighth magnitude, at a distance sufficiently great to cause a vast system of stars to put on the appearance of a very diluted milky nebulosity." Thus we find Sir William, one of the world's greatest astronomers, laying the foundation for conjectures and theories which have interested, and will continue to interest mankind, so long as there is any doubt about these bodies, or so long as there is any outward twilight into which the inquiring mind can penetrate. He had wandered into the dim distance, until lost amid the shadows and darkness of unexplored regions, and was forced to adopt the course which appeared to be

supported by the strongest probabilities. One of the positions increased his bewilderment; while the other pointed out the way of return, but left him standing astounded by his own discoveries, and the remarkable deductions to which they would inevitably lead.

There were other phenomena, however, which greatly contributed to establish the idea of a phosphorescent vapor, or elementary form of luminous sidereal matter; the most important of which is known as the zodiacal light, which is seen after sunset during the spring months, and before sunrise during the fall. It is a cone of lenticularly-shaped light, extending from the horizon obliquely upward, following generally the course of the ecliptic, or rather that of the sun's equator. It has been contended that this was a residuum of the nebulous matter, or star-dust, collected around the sun. An acceleration discovered in the motion of the moon, which, it was supposed, resulted from the resistance of an ethereal medium in which the heavenly bodies revolved, also united with the various concurring phenomena to establish the belief in the existence of this highly attenuated vapor; out of which nature elaborated her suns and planetary systems by the powers of attraction and gravitation. This belief was also favored by the crepuscular theory of light. It

was supposed that the waste of the celestial bodies, by the perpetual diffusion of their light, was compensated by this collecting and condensing process, and the balance of the system restored by the formation of new planets and stars. Indeed, the general harmony that prevailed throughout the mechanism of the whole system, seemed to strengthen the various evidences, and establish the theory. This harmony, so delightful to the astronomer, could be most satisfactorily accounted for by supposing the planets to have been thrown off from the sun by centrifugal force, as the mighty primary swept around with incalculable speed. It was contended that the dimensions of the nebulous matter, which extended beyond the orbit of the most distant planet, were contracted by loss of heat through radiation; and that rotary motion was produced by the force of the outward particles rushing to the centre, and that this rotary motion caused centrifugal force, which threw off the outward particles, whenever it gained the ascendency over the power of attraction.

These speculations of the elder Herschel, concerning the possible aggregation of the self-luminous particles, and their condensation into planets, were followed by the "Nebular Hypothesis" of Laplace, a philosopher, whose varied and profound attainments enabled him to systematize the speculations

of others, and to erect a glorious temple in honor of man, out of the abundant and rich materials which the learned and great of all preceding ages had scattered around his feet. It was suggested, in his hypothesis, that the stars and planets were originally the same as the supposed nebulous bodies, and that they had passed regularly through the various stages of advancement or growth, necessary to prepare them for the habitation of animate matter; and that when in the course of this natural process, they were fitted for the great offices of life, they were left under the influence of certain arbitrary physical laws, to perform their part in the innumerable and brilliant sisterhood.

The first motion of this infant world of attenuated vapor, thrown off by laws originally stamped on matter itself, strikes the student with astonishment, barely sufficient to prepare him for the future revelations of which these early evidences of life are but feeble intimations. The changes and motions of the new-born planet will be observed through innumerable centuries of time, divided only by the immeasurable periods required for the birth of other and younger planets and planetary systems. The first and eldest of the sisterhood, sweeping around the outward horizon, will be lost in darkness to all unaided vision, long

before the junior members are prepared to cheer it with the warmth and gladness of the parent light.

The existence of the nebulous matter appeared to be satisfactorily proved by these phenomena. Nothing now remained to perplex the minds of astronomers, but the questions which grew out of the original observations of the nebulous matter; indeed, it was these subsequent questions which gave the first so much importance. How far did the great primary nebula extend? From whence did it come, and what is its destiny? The nebular hypothesis begins with the supposition that it originally extended beyond the orbit of the most distant planet, and that by loss of heat, through radiation, it contracted its dimensions, and that the inward rushing of the outward particles caused its rotary motion. This rotary motion gave birth to centrifugal force, which continued to increase with the condensation of the body, until it threw off the external particles into a separate zone or ring, as the rings of Saturn. These were broken up by some imaginary influence, and the particles again drawn together by the attractive power of a central point, which became the nucleus of the new-born planet. This in its turn is put into motion by the same forces, and throws off other rings, which by a similar process are transformed into revolving satelites. Thus.

step by step we are led to look upon the world of matter as one vast field of changing elements. Harmonious, however, in all its various changes. The laws which at first appeared to act against the system, rending the particles asunder, and scattering them to the winds of heaven, are the chief workmen in reconstructing the fragments, and in extending the mighty family of planetary and stellar systems.

As additional proof of the truth of this remarkable hypothesis, we are directed to the appearance of the planets and satellites; their distances, densities, and motions, which, it is contended, confirms the theory of their creation. The first planet thrown off must necessarily be the largest and least compact, as well as the most remote member of the system. As the mass continues to contract and solidify, the second planet must be smaller, and its constituent particles closer than the senior member; and so through the whole system, in proportion to the distance the various members are located from the great central primary; and as they are all thrown off by the same forces, they must move necessarily in the same direction. Truly, these were suppositions worthy of the consideration of the greatest minds, and so they were received. They aroused the philosophic world, and gave point and energy to its observations. Before this period, astronomers appear to have been stimulated in their labors chiefly by the

love of the wonderful, and the disposition, so predominant in some minds, to wander into unknown regions. But now astronomy appeared more interesting and infinitely more important. It was now believed to be the key by which the mighty archives of the universe were to be unlocked, and the hidden mysteries and forces of Nature's creative agencies (not to speak irreverently) revealed to the gaze of mortals. The feeble representative of the great designing INTELLIGENCE was to be introduced, uncovered, and trembling though it might be, to the sublime and awful forces which work out the designs of the INFINITE and the ETERNAL. No wonder that astronomy assumed an increased importance, and that the initiated waited for farther revelations with deepening anxiety.

For years the far-reaching vision of astronomers had been turned upon these appearances, and for an equal length of time the learned corps had been defeated and mortified by the uncertainty in which they were compelled to remain; while theories, as wild as the nebulæ are distant and indistinct have resulted from their irresolvability, which have alternately disturbed the foundations of the Christian religion and the science of astronomy itself—that glorious star-crowned superstructure, whose arches span the widest range of stellar matter. These irre-

solvable islands were found in the very borders of that vast field which the astonishing improvements of man have enabled him to bring within the compass of his vision, and therefore were the more difficult to examine. But, as successive improvements were constantly enlarging the field of view, and rendering more distinct the remote territory already partially surveyed, it was hoped that these phenomena would soon be understood. That period has now arrived. Out of the dark cloud that settled on the bosom of philosophy, light and truth have been distilled, and science comes out more closely allied to the religion which sustained her faithful priesthood.

It was believed by Sir William Herschel, that many of the nebulous bodies would eventually be resolved into clusters of stars, and hence he divided them, as we have seen, into different classes; but he as firmly believed that the nebulæ proper would never be resolved into stars. A similar opinion, stated, however, with less confidence in the existence of nebulous matter, was advanced by his distinguished son, Sir John Herschel, at a recent period. In speaking of these bodies, at one of the meetings of the British Association, in 1845, he said: "By far the major part, probably at least nine-tenths of the nebulous contents of the heavens, consist of

nebulæ of spherical or elliptical forms, presenting every variety of elongation and central condensation. Of these a great number have been resolved into distinct stars, and a vast multitude more have been found to present that mottled appearance which renders it almost a matter of certainty that an increase of optical power would show them to be similarly composed. A not unnatural or unfair induction would therefore seem to be, that those which resist such resolution, do so only in consequence of the smallness and closeness of the stars of which they consist; that, in short, they are only optically, and not physically, nebulous. There is, however, one circumstance which deserves especial remark, and which, now that my own observation has extended to the nebulæ of both hemispheres, I feel able to announce with confidence as a general law, viz: that the character of easy resolvability into separate and distinct stars is almost entirely confined to nebulæ deviating but little from the spherical form; while, on the other hand, very elliptic nebulæ, even large and bright ones, offer much greater difficulty in this respect. The cause of this difference must, of course, be conjectural; but I believe it is not possible for any one to review *seriatim* the nebulous contents of the heavens, without being satisfied of its reality as a physical character. Possibly the limits of the con-

ditions of dynamical stability in a spherical cluster may be compatible with numerous and comparatively larger individual constituents than in an elliptical one. Be this as it may; though there is no doubt a great number of elliptic nebulæ in which stars have *not* yet been noticed, yet there are so many in which they *have*, and the gradation is so insensible from the most perfectly spherical to the most elongated elliptic form, that the force of the general induction is hardly weakened by this peculiarity; and for my own part I should have little hesitation in admitting all nebulæ of this class to be, in fact, congeries of stars. And this seems to have been my father's opinion of their constitution, with the exception of certain very peculiar-looking objects, respecting whose nature all opinion must for the present be suspended. The wildest imagination can conceive nothing more capricious than their forms, which in many instances seem totally devoid of plan, as much so as our real clouds; others offer traces of a regularity hardly less uncouth and charac teristic, and which in some cases seem to indicate a cellular, in others a sheeted structure, complicated in folds, as if agitated by internal winds." "Should the powers of an instrument such as Lord Rosse's succeed in resolving these also into stars, and, moreover, in demonstrating the starry nature of the regu

lar elliptic nebulæ which have hitherto resisted such decomposition, the idea of a *nebulous matter*, in the nature of a shining fluid, or condensible gas, must, of course, cease to rest on any support derived from actual observation in the sidereal heavens, whatever countenance it may still receive in the minds of cosmogonists, from the tails and atmospheres of comets, and the zodiacal light in our own system. But, though all idea of its being ever given to mortal eye to view aught that can be regarded as an outstanding portion of primeval chaos be dissipated, it will by no means have been then demonstrated, that among these stars, so confusedly scattered, no aggregating powers are in action, tending to draw them into groups, and insulate them from neighboring groups; and, speaking from my own impressions, I should say that, in the structure of the Magellanic clouds, it is really difficult not to believe we see distinct evidences of the exercise of such a power." This language was held by a learned astronomer, on the very morning of the greatest discoveries ever made by man.

II.

THE RESULTS OF INCREASED POWER.

According to the predictions of these distinguished philosophers, it was found that each increase of instrumental power made large additions to the catalogue of resolvable nebulæ. Nebulæ which appeared as dim, milky spots, scarcely perceivable to Sir William Herschel, burst into splendid galaxies under our present second-rate instruments. In fact, nearly all of the nebulæ which resisted the power of his telescope yielded successively to the instruments which followed in the train of improvement. A dim spot, shining out from the far-off distance, as an irregular aggregation of "star-dust," was resolved by Lord Rosse's three-feet telescope, into his Lordship's splendid Crab Nebula, which is now known to be a mighty system of brilliant orbs, more splendid perhaps than the one of which our planet constitutes a comparatively insignificant, yet necessary part. The circular nebula of Lyra, less distinct even than the Crab Nebula, was not fully resolved by that instrument; but sufficiently so to convince astronomers that its resolution was near, and that it, also, was a mighty galaxy. The most indistinct—those found on the

very verge of the horizon of the longing eye of science, the Dumb Bell and Dog's Ear, for example —were more difficult to resolve. The first of these, however, appeared through that instrument as a wonderful system, clustering around two nuclei or knots of stars. The last required the extraordinary power of Lord Rosse's six-feet mirror to resolve it. This nebula presented the most astonishing figure; and it is not less an object of profound interest, although it is now believed to be a cluster of distinct stars, than when it lay dimly shining mid the darkness of the unexplored regions of space. He who can view these phenomena without feeling his own insignificance in the vast universe around him, and bowing with reverential awe before the Almighty Power on whose will all these mighty systems hang trembling in their orbits, must have a singular composition of faculties, darkened by passion or deadened by improper education, exciting the sympathy not only of angels, but of their Creator himself.

Thus far, these bodies, by yielding to the progressive steps of science, have thrown light upon the darkness by which they were surrounded, and gradually prepared us for the revelations which were reserved for the immense space-penetrating telescope of Lord Rosse, and the less renowned but equally astonishing mirror at Cambridge. These telescopes,

themselves the grandest achievement of art, have opened up new and deeply interesting territories for the contemplation of man. Dim and distant nebulæ, so remote that it required sixty thousand years for their light to reach us, burst upon the long-reaching vision of these mighty instruments with a grandeur before unknown. The nebula in Andromeda, discovered in the tenth century, and the only one out of four thousand which was discovered before the invention of the telescope, has been resolved by the great refractor at Cambridge, but by no other instrument. Sir John Herschel described it in 1826, as a nebula of a milky appearance and perfectly irresolvable, not having the slightest tendency to that separation into flocculi, seen in the nebula in Orion, and having no appearance of a star in the centre. In August, 1847, the Cambridge refractor was directed upon it, when the centre appeared condensed almost into a star-like nucleus, and a vast number of stars, of every gradation of brilliancy, rose upon its surface, not, indeed, fully and distinctly defined, but showing clearly that they were not component parts of it. On the fourteenth day of September following, a favorable opportunity for farther investigation offered itself, when, by directing the attention to the preceding portion of the nebula, says Mr. Bond, as it passed the centre of the field of view, it was evi-

dent that what had hitherto been regarded as its boundary in that direction, was rather a sudden interruption of light, appearing like a narrow, dark band, in which the eye could detect no deviation from perfect straightness, stretching in the direction of the axis of the nebula, entirely across the field of vision. Exterior to this, with respect to the axis, was another band or canal, closely resembling the former, but somewhat less distinct, of equal regularity, and so nearly parallel with it as to make it difficult to decide, by simple inspection, whether they were not perfectly so. What particularly commands attention here, is the regularity of structure displayed—the uniform influence, made manifest to the senses, of the same law, over an immensity of space of which the mind can form no adequate conception; since the distance at which Sir William Herschel placed this nebula requires that the length of the interior canal should not be estimated at less than twenty times the distance of Sirius from our system. The number of stars visible with the full aperture of the object-glass within the limits of the nebula, prevented Mr. Bond from attempting to execute a map of them; but it was thought that two hundred at least could be seen in a single field of the telescope. This is nearly equal to the number found in a single field of view in the Milky Way. With high powers minute stars can be

discerned on the borders of the nucleus; and although it cannot be said that this extraordinary body has been fully resolved, yet its character can be the subject of speculation no longer.

But we turn to the last and perhaps the most wonderful of these bodies, the nebula in Orion. On examining this nebula through telescopes of ordinary power, the middle star seems affected by an indistinctness not common to small stars; indeed, it appears rather as a diffused haze, not a star properly, and even when examined with instruments of still greater power, this hazy appearance continues unchanged. When Sir John Herschel's eighteen-inch mirror was directed upon it, strange and fantastic branching arms were discovered, with such an extraordinary appearance as to induce Sir John to believe it to be something very different from a stellar constellation. In the winter of 1845, Dr. Nichol examined this nebula through Lord Rosse's six-foot mirror, after which he says, "owing to the incompleteness of the instrument, and the unfavorable weather, it was the first time that grand telescope had been directed towards that mysterious object. Not yet the trace of a star; looming, unintelligible as ever, there the nebula lay. But how brilliant its brighter parts! How much more broken the interior of its mass! How innumerable the streamers now attached to it

on every side! How strange, especially that large horn, rising in relief out of the dark skies, like a huge cumulous cloud! It was still possible, then, that the nebula might be irresolvable by the loftiest efforts of human art; but doubt continued to remain." The long-cherished hopes of the Professor were all blasted. He who had measured the heavens, and furnished us a geography of its wide domain, with the size, location, and motions of the starry hosts, was compelled to turn once more from the contemplation of this wonderful phenomenon with feelings of profounder reverence and awe. Not discouraged, however, by the failure of the first effort, the distinguished owner of the "Parsonstown Leviathan" continued his observations at every favorable opportunity, until March, 1846, when his labors were crowned with success. He was enabled, not indeed to resolve this obstinate body fully, but sufficiently to satisfy himself and others that it was undoubtedly a splendid galaxy of stars, which fact he communicated to Professor Nichol the morning following his success. No longer a self-luminous vapor, or planet in its infancy, but a bright firmament of stellar orbs, so far removed from us in space, that the brilliancy of its constituent stars is merged into a uniform, faint light. The difficulty was removed, and all the strange appearances accounted for as the effect of varying distances. The

stars of heaven are perfect; no rudimental or half-grown ones are found; the choir is full. The Nebular Hypothesis vanishes as a pleasant dream, profitable though we believe it has been; and with it various systems of cosmogony, the fear of timid Christians, and the hopes of Atheistical philosophers.

When the drawing of that nebula, as seen through Lord Rosse's grand telescope, was shown to Sir John Herschel, he said he felt an inexpressible delight when contemplating the achievements of that instrument, that, by opening up new scenes of the grandeur of creation, it would tend to elevate and ennoble our conceptions of the great and beneficent Architect, and that that was the grand object contemplated, and the noblest aim of all science. He who

> ——"Spangled o'er infinity with suns,
> And wrapped it round about him as a robe,
> And wrote out His own great Name
> In spheres of fire, that Heaven might alway tell
> To every creature, God!"

rises above the majestic movement of his own creation, bidding man, in gentle but reproving language, to gird up his loins and declare, whether he can "bind the sweet influences of the Pleiades, or loose the bands of Orion!"

The dark cloud which had so long obscured the vision of astronomers, not only preventing further

investigation, but casting heavy shadows upon objects already surveyed, and doubts and fears upon facts which otherwise would have served as a sure foundation for hope and faith, had, at least, been broken into detached parts, and now only waited the agency of the splendid telescope at Cambridge, to be resolved into thinner vapor than the most highly attenuated nebulæ, which was ever supposed to have an existence. The Cambridge refractor has not the space-penetrating power of Lord Rosse's telescope; but our atmosphere is more favorable, and hence more has been achieved than has yet been accomplished by that immense instrument. When the Cambridge refractor was directed upon the nebula in Orion, the stars of that immeasurable mass burst into the most distinct and well-defined light. The learned director of that Observatory has executed a splendid drawing of the nebula, locating and numbering a catalogue of several hundred stars, varying in his scale from the fourth to the nineteenth degrees of magnitude. The nebulous appearances are not entirely dissipated; nor can we hope they ever will be. From past experience we may expect, that as the space-penetrating power of the telescope is increased, the present nebulous appearances will be resolved into stars, and that other nebulous appearances, still more remote, will rise upon our vision, to perplex the

inquirer, and to invite renewed efforts; but telling man, in silent yet astounding language, that beyond, and still beyond, there are other systems, too mighty and too remote for his limited vision; that there are no bounds to space or to matter; and that to the Infinite Mind, the power to scan the illimitable and comprehend the incomprehensible, has been reserved.

What infinite distances, what dread potencies, are here for our contemplation! But above these potencies, mighty though they are, we cannot fail to recognize a Creative Power, more worthy of our serious and reverential contemplation. 'Twas He who spread out these illimitable fields of space; who created and now controls the mighty forces pervading them; to whom the deep-toned thunders and whispering zephyrs are alike obedient. To Him all times, all distances, and all things, are the same. The delicate flower, breathing its fragrance upon the thoughtless wanderer for a day, and the dim, yet mighty systems, sweeping with incalculable speed around the verge of the outward horizon; my infant daughter, yet unconscious of the dread agencies around her, reminding us by her simplicity and innocence, of primal purity; and the throng of angels, the loved and lost, "whose bright and long-missed faces seem bursting through the sky," are all the creatures of His infinite love, and the objects of His parental care.

" The smallest dust which floats upon the wind
Bears the strong impress of the ETERNAL MIND:
In mystery round it, subtle forces roll;
And gravitation binds and guides the whole.
In every sand before the tempest hurled,
Lie locked the powers which regulate a world;
And from each atom human thought may rise
With might to pierce the mysteries of the skies;
To try each force which rules the mighty plan,
Of moving planets, or of breathing man,
And from the secret wonders of each sun,
Evoke the truths and learn the power of God!"

PART II.

ASTRONOMY.

1.

From the review of the phenomena upon which the Nebular Hypothesis was based, themselves depending on suppositions and conjectures, we turn to facts equally interesting to the candid inquirer, and infinitely more important in guiding the mind to correct conclusions, and the heart to the great source as well as end of all its best affections.

A distinguished jurist, when speaking of circumstantial evidence, said that it might be, and not unfrequently was, better than direct and positive proof. The ear and eye may be deceived; but an unbroken chain of dependent circumstances, standing in the relation of cause and effect, or of independent facts, all tending to establish the same hypothesis, and to exclude every other analogous to the *reductio ad absurdum* in geometry, amounts to proof almost

above the possibility of error. And although proof of this kind is seldom of an absolute or demonstrative character, yet it is sufficient to exclude all reasonable doubt, and thus generate moral conviction and belief. The most important and beautiful of all philosophical theories, that of Sir Isaac Newton, for explaining the solar system, as exhibited by that great philosopher, amounts simply to this; a cause, viz., gravitation exists. It is matter of demonstrative proof, that if such a cause did really operate upon the system, it would produce all the effects or phenomena which are actually observed; that is, the supposed cause is sufficient to explain all the phenomena, hence it is inferred to be true; and the force of this inference is in proportion to the improbability that all the minute coincidences between the phenomena and the hypothesis should be merely fortuitous, and that they should have resulted, not from a cause known to exist, and which is adequate to produce them, but from some other cause unobserved and unknown. And in philosophical, as in judicial proofs, the chain of coincidences, and the chain of circumstances proved to exist, must be perfect and unbroken; the least chasm will destroy the whole. If there are any incongruous circumstances or facts which cannot be removed, or any chasm which cannot be filled, the hypothesis must fall, although no other can be sug-

gested. So true is this, that the French philosophers opposed Newton's system of the world, because his calculations made the moon's apsides but one half as great as they were proved to be by actual observation. And this, be it remembered, was after every other difficulty had been removed.

The problem of the three bodies challenged the greatest minds of the eighteenth century, and threatened the total overthrow of that system, which is both the glory of Newton, and the honor of his species. Clairaut, D'Alembert, and Euler, were the three distinguished competitors for the honor of removing the difficulty. And it was not until they discovered that the difference between the calculations of the apsides and the actual observation, resulted from an error in neglecting a tangential force in the calculation, which, when taken into the account, reconciled the theoretical with the actual observation, that the French fully adopted Newton's theory.

Clairaut found that the motion of the longer axis of the moon's orbit came out only half of what observation made it. In consequence of this, he came to the conclusion that the force with which the earth attracts the moon, does not decrease exactly as the square of the distances increase; but that a part of it only follows that law, while another part follows the inverse of the biquadrate or fourth power of the dis-

tances. This was objected to for want of simplicity. On farther calculation he was induced to carry his approximation farther than he had done, and to include quantities before rejected. Having done this, he found the numerator of the fraction that denoted the part of gravity which followed the new law, equal to nothing; that is, that it had no existence. The calculus was then rectified, and the approximation carried out, when it was clearly and satisfactorily settled that the moon's apsides, as deduced from theory, coincided exactly with observation. This was an important triumph for science, connecting as it did, the mighty chain of facts which established Newton's theory. Gravitation was then acknowledged by the learned of all countries, to be as mighty as it was mysterious; as regular and powerful as it was universal and essential in the glorious family of brilliant orbs, whose pathways it marked out and whose revolutions it controlled.

The orbits of the planets are all ellipses, having the sun for their common focus. The distance of the focus from the centre of the ellipsis is what astronomers call the eccentricity of the orbit. This eccentricity is small in all of the planets, and the ellipse approaches nearly to a circle. These eccentricities are subject to constant changes, but they are so influenced and regulated by each other, that the change is

never very great. This fact was clearly and satisfactorily established by Laplace, in his "*Traité de Méchanique Céleste.*" If the mass of each planet be multiplied into the square of the eccentricity of its orbit, and this product into the square root of the axis of the same orbit, the sum of all these quantities, when they are added together, will remain for ever the same. This sum is a constant magnitude, which the mutual action of the planets cannot change, and which nature preserves free from alteration. Hence no one of the eccentricities can ever increase to a great magnitude; for as the mass of each planet is given, and also its axis, the square of the eccentricity in each is multiplied into a given co-efficient, and the sum of all the products so formed is incapable of change.

The orbits of the planets, however, are not all alike. They differ in form as well as distance. Whether this was designed by the great ARCHITECT, or resulted accidentally from the different degrees of velocity with which the planets were originally thrown off from the supposed nebulous primary, can be inferred from the evidence only which their diversified forms and their necessary forces present. Had the velocity been such, says a distinguished authoress, as to make the planets move in orbits of unstable equilibrium, their mutual attraction *might* have

changed them into parabolas, or even hyperbolas, so that the earth and the planets *might*, ages ago, have been sweeping far from our sun, through the abyss of space. But as the orbits differ very little from circles, the momentum of the planets, when projected, must have been exactly sufficient to insure the permanency and stability of the system. Besides, continues the same authority, the mass of the sun is vastly greater than that of any planet; and as their inequalities bear the same ratio to their elliptical motions, that their masses do to that of the sun, their mutual disturbances only increase or diminish the eccentricities of their orbits by very minute quantities; consequently the magnitude of the sun's mass is the principal cause of the stability of the system. Thus we see that the orbits of the planets are important elements; and we must also see that they were originally designed to perform the office which we find them performing in the system. It would be useless to inquire, whether the CREATOR chose to establish them through the intensity of their primitive momentum, or independent of it; it is enough to know that the forces exerted by them are necessary in the system, and that these forces result from peculiarities which cannot be accounted for, and which might have been different. This important and necessary arrangement has always been consider-

ed an interesting and conclusive evidence of original design; because it depends on conditions arbitrary in themselves. The quantity which secures the stability of the system depends on the uniform motion of the planets, their circular orbits, and the smallness of their eccentricities; all of which might have been different from anything we can discover in the laws pervading the universe.

The inequalities of the planets, for a correct understanding of which the world is indebted to Lagrange, are also interesting and important evidence of original design or final cause. Lagrange found that the inequalities were all periodical; and that the greater axis of the ellipse, or the mean distance of each planet from the sun, and its mean motion, were always the same. This was one of the greatest discoveries of science. It was then ascertained that these inequalities were limited; and that, although the planets under the influence of one law did wander from their course, they were drawn back again by a potency equal to the former; and that the discord and destruction which would necessarily result from the supremacy of either power, was prevented by a just and equal balance of both.

In this connection we may refer to the acceleration of the moon, discovered by Dr. Halley, while comparing ancient with modern observations. This, it

will be recollected, was one of the evidences relied on to establish the existence of a nebulous matter. Dr. Halley observed that the moon's motion around the earth appeared to be performed in a shorter time than was formerly required; and that the difference appeared to be slowly but regularly increasing. This could not be explained by gravitation. It was supposed by many savans, that gravitation did not act instantaneously, and that the time thus taken up caused the acceleration; others thought it was caused by a resistance of the medium in which she moves. The last opinion was adopted by the friends of the nebular hypothesis. It was reserved for Laplace to show how this acceleration agreed with the inequalities depending on the changes in the eccentricities of its orbit, and that it is not constantly increasing, but like other inequalities, periodical. It was these unexplained accelerations and inequalities, favoring the idea of a final destruction of our system, that inspired the eloquent lines of the philosophic Darwin:—

"Roll on, ye stars! exult in youthful prime,
Mark with bright curves the printless steps of Time.
Near and more near your beamy cars approach,
And lessening orbs on lessening orbs encroach.
Flowers of the sky! ye too to age must yield,
Frail as your silken sisters of the field,

Star after star from heaven's high arch shall rush,
Suns sink on suns, and systems systems crush;
Headlong, extinct, to one dark centre fall,
And earth, and night, and chaos mingle all;
Till o'er the wreck, emerging from the storm,
Immortal NATURE lifts her changeful form;
Mounts from her funeral pyre on wings of flame,
And soars and shines another and the same!"

"The destiny of nature is, however," to use the language of Professor Playfair, "more noble than that which this magnificent description holds up to the fancy; and the algebraist has extracted from his calculus a more sublime conclusion than the invention of a poet has been able to attain. The constancy of nature, amidst all the changes she undergoes, is upheld by the constitution of these changes, which prescribes to each its limits, and forces it to recur in a series, which in time reduces to nothing the sum of all the deviations from the mean. Thus, the amount of the whole is permanent, though the terms themselves are perpetually changing; and hence nature is rendered immortal, not by emerging from the storm, but by being ever superior to its power; its order is not renovated, but preserved; and the wisdom of its AUTHOR has provided an antidote to evil, that renders all remedies unnecessary."

But we return to the nebular hypothesis, according to which the nebulous matter must have originally

filled all space, and all celestial bodies of every character most have resulted or sprung from it. They should, therefore, all move in the same direction around the primary, and should observe some law as to the relative time required to complete that motion; secondly, they should rotate in the same direction on their axes; and thirdly, the satellites should observe the same laws towards their primaries. And as the great primary continued to solidify as it contracted its dimensions through the influence of radiation, the inner or nearest planets should be more compact than the outer ones; and so in proportion to their distances, or the date of their creation. It is also contended that the size of each must agree with its distance from the primary: we do not think, however, that this is a necessary consequence.

At the expense even of repetition and prolixity, we must, before going any farther, refer to the positions first assumed. A nebula, extending through all space, is reduced by radiation, which in itself produces an inward rushing of the outward particles; and this causes rotary motion, which, in its turn, gives birth to centrifugal force. Now, without inquiring into the cause of this radiation, or the possibility of it in a body such as this diffused nebulous mass must have been, we will proceed to inquire how the revolving motion resulted from the inward rush-

ing of the molecules. This is explained by the whirlpools or dimples observed by the "musing poet" in fantastic eddies, where the current is forced out of its direction by some opposing power turning it back in a semi-circular course, which brings it in contact with the current above, and this carrying it down again to the point of resistance, gives it a circular motion. We see this illustrated in the bends or curves of rivers, where the current rushes against the bank, and at the meeting of streams flowing together from oblique directions. But these phenomena are not fair illustrations of the motion of the nebulous particles. The nebula must have been a globe: if so, the radiation acted equally on all the agglomerating particles in the same circle, and the momentum of each must have been the same. This neutralized their force, and destroyed all cause for rotary motion. Whirlpools are caused by currents running to different points; but the agglomerating particles of the nebula are all drawn to a single nucleus. The different currents have unequal force and velocity; but the motion of the molecules is produced by the same influences, and their forces are necessarily equal.

But suppose the external particles were thrown off in the form of a ring around the primary, and afterward broken up; we still meet with a

difficulty of no ordinary character, in getting them around a single nucleus. These fragments are scattered around an orbit too inconceivably vast for computation, and around a globe (the primary) millions of times larger than the nucleus which is destined to attract the widely scattered particles together. It is a well-known law in physics, that there is a mutual attraction between all bodies in the proportion of their mass. How, then, is the attractive power of the great central mass overcome by that of the mere point? Is it owing to a centrifugal force which continues to throw them off? We can imagine the planets taking oblate forms under the reciprocal attraction of their component parts and centrifugal force, for this process is natural, and does not conflict with well established laws; but how detached parts, under the influence of conflicting forces, separated as widely as these must have been, were brought under the attractive power of a single nucleus, is a question not easily settled.

The four minor planets, occupying the space between Mars and Jupiter, seem to be more natural, having been formed according to this theory, out of the same broken ring; but they constitute an exception to the general law, and are accounted for by supposing that a planet had been burst asunder by some internal force, after it had been formed out of

the particles thrown off from the primary. It appears more likely, however, that the broken ring would have originally formed around the different nuclei, and not around a single one.

But, did this supposed nebulous body ever occupy the whole orbit of the most distant planet? The diameter of the sun is eight hundred and eighty-eight thousand miles; and that of Jupiter, the largest planet, only eighty-eight thousand miles. It has been ascertained by calculation, that if all the planets and satellites in our system were moulded into a single globe, that globe would not exceed the five-hundredth part of the globe of the sun: in other words, the bulk of the sun is five hundred times greater than the aggregate bulk of all the rest of the bodies of the solar system. If the planets and satellites were brought to the density of the sun, they would still bear no greater proportion to that body. According to this calculation, we have a globe whose diameter is eight hundred and eighty-eight thousand miles, and other bodies, the aggregate bulk of which is but one five-hundredth part as large, of the density of water, to fill an orbit whose diameter is not much less than six thousand millions of miles. We repeat, is it possible that these bodies ever filled the orbit of Uranus? The discovery of Neptune increases the difficulty

We know the astonishing extent to which water may be expanded; but there are limits to the expansion of steam, as well as to everything else.

II.

THE DISTANCE AND DENSITY OF THE PLANETS.

And what are the distances and densities of the planets? for these are important elements in the theory. The nearest planet is thirty-six millions of miles from the sun, and the second is seventy millions of miles, or nearly twice the distance of its younger sister; while the earth, the next in order, is only ninety-five millions,—being less than one third increase on the orbit of Venus; and Mars, the fourth, is one hundred and fifty millions of miles, or a little more than one third increase on the orbit of the earth. Uranus is one billion eight hundred millions of miles from the sun, or nearly twice the distance of Saturn. But Neptune exhibits the greatest violation of the supposed law of planetary distances. The interval between its orbit and that of Mercury, instead of being nearly double the interval between the orbit of Uranus and Mercury, as the law requires, does not, in fact, exceed the latter interval by much more than one half its amount.

"This remarkable exception," says Sir John Herschel, "may serve to make us cautious in the too ready admission of empirical laws of this nature to the rank of fundamental truths, though, as in the present instance, they may prove useful auxiliaries, and serve as stepping-stones, affording a temporary footing in the path of great discoveries!" The space between Mars and Jupiter is accounted for by supposing that the planet originally thrown off in that place, was broken up by some internal violence; and that the four small planets first discovered, which revolve between these two planets, at nearly the same mean distance from the sun, were formed out of the fragments of the broken planet. This may be true, but how are the other small planets, recently discovered within our system, accounted for? The only vacancy in the order of the planets, lies between Mars and Jupiter: to fill that there are eleven small planets, which, if moulded into one, would make it too large for the law of proportion. Thus, while astronomers restore the apparent order of distances by reconstructing a large planet out of the small ones found in the chasm, they violate the law of increasing size. Every discovery removes some strong column from the vapory edifice, and adds new difficulties for the ingenious and the learned to surmount.

The same difficulty presents itself in the bulk or

size of the planets. Mercury, the nearest to the sun, is about three thousand two hundred miles in diameter, and Neptune, the most distant planet yet discovered, is not far from twenty thousand miles in diameter. There is not, however, a progressive increase of bulk from Mercury to Neptune. Jupiter, the fifth large planet, is much the largest, having a diameter of eighty-eight thousand miles. Saturn is larger than Uranus, being eighty thousand miles in diameter; and Uranus is nearly twice as large as Neptune. The diameters of Venus and the Earth are nearly equal, each of them being twice as great as that of Mars, whose distance from the sun is more than one third greater than that of the Earth, and more than twice the distance of Venus. There is, then, no regularity to be found here, however important an element it may be in the hypothesis. The measure of density adopted, and which is sustained by the exact calculation of some of the planets, reduces Uranus down to an inconceivably attenuated mist, and Neptune to "the shadow of a shade." The density of the planets is different, but not more regular in increase than in their size. Indeed, there is no law, either in their distance, size, or density. Appearances at first seem to indicate the existence of such laws, but observation and measurement establish exceptions to them, at once too numerous and too

great to admit of such a belief. The advocates of the theory are not more fortunate in the motion of the heavenly bodies; for it is found that the satellites of Uranus have a retrograde motion, that is, from east to west. This fact appears to be established; and it conflicts with calculations more important than the nebular theory. We will see hereafter that the uniform motion of all the bodies, including satellites, in one direction, is considered necessary to the stability of the system.

In connection with these differences, we may refer to the contrast between the interior and exterior planetary groups. The members of the interior group are denser, rotate more slowly and with nearly equal velocity, and are less compressed at the poles. The compression at their poles may be accounted for by their velocity, but beyond this there is no inherent necessity, no natural law, by which their peculiarities can be explained. The time of rotation diminishes with increasing solar distance, yet it is greater in Mars than in the earth, and in Saturn than in Jupiter. The same differences exist in the ellipticity of their orbits. Juno, Pallas and Mercury have the greatest degree of eccentricity. "The eccentricities of Juno and Pallas," says the illustrious Humboldt, "are very nearly identical, and are each three times as great as those of Ceres and Vesta. The same may be

said of the inclination of the orbits of the planets toward the plane of projection of the ecliptic, or in the position of their axes of rotation with relation to their orbits; a position on which the relations of climate, seasons of the year, and length of the days depend, more than on eccentricity. Those planets that have the most elongated elliptic orbits, as Juno, Pallas, and Mercury, have also, though not to the same degree, their orbits, most strongly inclined toward the ecliptic. Pallas has a comet-like inclination nearly twenty-six times greater than that of Jupiter; whilst in the little planet, Vesta, which is so near Pallas, the angle of inclination scarcely by six times exceeds that of Jupiter. An equally irregular succession is observed in the position of the axes of the few planets whose planes of rotation we know with any degree of certainty. It would appear from the position of the satellites of Uranus, two of which, the second and fourth, have been recently observed with certainty, that the axis of this planet is scarcely inclined as much as eleven degrees toward the plane of its orbit; while Saturn is placed between this planet, whose axis coincides with the plane of its orbit, and Jupiter, whose axis of rotation is nearly perpendicular to it. * * * *

The planetary system, in its relations of absolute size, and the relative position of the axis, density, time

of rotation, and different degrees of eccentricity of the orbits, does not appear to offer to our apprehension any stronger evidence of a natural necessity, than the proportion observed in the distribution of land and water on the earth, the configuration of continents, or the height of mountain chains. In these respects we can discover no common law in the regions of space, or in the inequalities of the earth's crust."

We have noticed every evidence which contributed to support the nebular hypothesis, except those derived from the crepuscular theory of light, and the zodiacal light; and we have found that the evidences themselves either had no existence, or that they proved the reverse of the theory. The crepuscular theory of light has yielded to another more reasonable, and which agrees more fully with known phenomena. While the writer does not believe in the correctness of either of the theories of light, he considers the undulatory the most reasonable and probable. This certainly does not agree with the idea advanced by the friends of the hypothesis; and the other theory is almost entirely superseded. The uncertainty which continues to hang about the origin, character, and destiny of the zodiacal light, prevents us from speaking as positively concerning it. But we believe that future discoveries will also rob the hypothesis of this, its

last support; for the same discoveries will, if the the past have not already, remove even the shadow of an argument, so far as the appearances of the Magellanic clouds are concerned.

But we pass from negative to positive evidence; from the imaginary evidences of an empty theory to the astonishing facts and beautiful adaptations of a glorious reality. While speaking of the planets, their axes, orbits, and eccentricities, we were necessarily compelled to anticipate this part of the subject; for it appeared impossible to pass them by without alluding to the evidences of design, which were written in characters as bright as the sunlight in which they revolved. Many of the arrangements to which we have referred, although they are, as we have seen, indispensably necessary in the harmoniously acting machinery of the universe, do not result from any known physical law, and cannot be accounted for by any thing within the compass of scientific research. They are not the offspring of gravity, that mysterious power which pervades the universe, and binds the various parts in relations of dependency. Without them, the harmony and beauty, as well as the permanency of the system, would be lost; yet they appear independent of all physical laws, and must depend upon some power without and above the solar system, if upon any. God, who created and designed the

various parts to perform their respective offices, wrote out the law of their existence in the act of their creation. "Thus far and no farther;" to that end and no other, spake the ALMIGHTY at the time he separated the heavens from the earth, and drew the boundary line between the dry land and the watery deep; and thus, when HE scattered HIS starry host, and planted HIS planetary sentinels through the infinitude of space, were their axes fixed, their orbits prescribed, and their eccentricities limited.

"He spake, and it was done; eternal night,
At GOD'S command, awakened into light;
HE called the elements, earth, ocean, air—
HE called them when they were not, and they were.
HE looked through space, and, kindling o'er the sky,
Sun, moon, and stars, came forth to meet HIS eye.
HIS SPIRIT moved upon the desert earth,
And sudden life through all things warm'd into birth.
Man from the dust, HE raised to rule the whole;
HE breathed, and man became a living soul;
Thus were the heavens and all the hosts displayed,
In wisdom thus were earth's foundations laid."

To confirm this, the smallest insect beneath our feet—the creature of a moment's duration—and the mighty planetary and stellar systems, scattered through infinity, in a single revolution of which unnumbered years are exhausted, unite their testimony. Each is a mystery beyond the comprehension of man, and both silently point him upward for the revelation he seeks.

III.

PHYSICAL LAWS. M. POISSON'S LABORS.

In speaking of the eccentricities of the planetary orbits, we referred to the evidences of Clairaut, Lagrange, and LaPlace, to show that the planets were so controlled by physical forces or laws, that they would always observe a mean; that if they did wander they would surely return; and that thus all danger to the system was avoided: to this we may add what is indeed a most important fact, furnishing as it does the most conclusive evidence of original design. The same distinguished astronomers succeeded in proving, that the eccentricities and inclinations of the planetary orbits, and the revolution of all the bodies in the same direction, were conditions necessary to secure the stability of the system. More recently it was asserted that the periodicity of the terms of the series expressing the perturbations was sufficient within itself; but this proved to be a mistake. M. Poisson has shown that the three conditions referred to are requisite for the necessary convergence of the series, and are therefore indispensable elements. It appears from this, that the conditions which man's imagination converted into the elements

of destruction, are the ones which the CREATOR made essential to the system. The stone which the builders rejected has become the corner-stone of the mighty edifice, the simplest component parts of which are beyond the comprehension of man. The talents and accumulated learning, and the untiring perseverance of centuries, have enabled him to weigh the planetary bodies and measure the immensity of their orbits, and partially to comprehend the mysterious forces which bind them in one great system; but beyond this he has not been able to penetrate. The inner sanctuary of the Almighty's dwelling-place, and the innumerable potencies which move the hidden machinery, have not yet been exposed to the gaze of mortals.

The planets are constantly subjected to, and are influenced by, certain forces which move them in different ways; yet the counter influences of these forces, and the attractive power of the sun, prevent these variations from becoming great. But minute as these changes or variations are, says the distinguished authoress heretofore referred to, they might be supposed to accumulate, in the course of ages, sufficiently to derange the whole order of nature, to alter the relative positions of the planets, to put an end to the vicissitudes of the seasons, and to bring about collisions which would involve our whole system, now so harmonious, in chaotic confusion. It is

natural to inquire, what proof exists that nature will be preserved from such a catastrophe? Nothing can be known from observation, since the existence of the human race has occupied comparatively but a point in duration, while these vicissitudes embrace myriads of ages. The proof, however, is simple and conclusive. All the variations of the solar system, secular as well as periodic, are expressed analytically by the sines and cosines of circular arcs, which increase with the time; and as a sine or cosine can never exceed the radius, but must oscillate between zero and unity, however much the time may increase, it follows that when the variations have accumulated to a maximum, by slow changes, in however long a time, they decrease by the same slow degrees till they arrive at their smallest value, again to begin a new course; thus for ever oscillating about a mean value. This circumstance, however, would be insufficient, were it not for the small eccentricities of the planetary orbits, their minute inclinations to the plane of the ecliptic, and the revolutions of all the bodies, as well planets as satellites, in the same direction. These secure the perpetual stability of the solar system.

But suppose it is admitted that all these conditions and coöperating forces might result, or even that they did result from the laws of gravity and centrifugal

force, and that these laws are self-existent, or necessary to matter itself, which is not contended for; yet, when we find that these conditions are necessary to the existence of the vegetable and animal kingdoms, and that the earth—for we can speak positively of no other body—would be a waste in the great creation if it were not for the laws which cause its rotation and revolution, and regulate its axis and orbit, can we resist the conviction that every part is the work of an all-wise INTELLIGENCE, to whom the past and the future are known, and to whose will all agencies are obedient?

While the earth revolves around its own axis, it moves in an elliptical orbit around its primary, the sun. In this annual motion the axis of the earth is inclined from the perpendicular to its orbit at an angle of twenty-three degrees and twenty-eight minutes; and during the time of the motion, the diameter is kept parallel to the same direction. By this simple but stupendous contrivance, the changes of the seasons and temperature are effected. Had the axis of the earth been perpendicular to the plane of its orbit, like Jupiter, (and we see no physical cause to have prevented it,) the same places would have had the sun always vertical. Under such an arrangement the equatorial regions would have been parched with intolerable heat, and that which is now the fairest portion of our

globe would have been doomed to sterility and desolation. By this inclination of the earth's axis, all parts are brought more or less under the solar influence; and thus the various climates are modified. But there are other elements equally important in producing the variety of seasons, and in securing the beautiful and necessary alternations, which make our globe the scene of such varied and ever-active life. We are nearer the sun during the winter than we are during the summer; the difference in the temperature of the seasons does not therefore depend on proximity to the sun, but on the time the terrestrial surface is exposed to its rays, and the manner in which they are received, whether vertically or obliquely. During our near approach to the sun, (for the earth is about one twenty-ninth of its whole distance from the sun nearer to it during its perihelion than it is during its aphelion,) its velocity is increased in proportion to the decrease of the square of its distance. It is this increased angular velocity of the earth, when at its perihelion, that protects us from the excess of heat to which our comparatively near approach to the sun would otherwise expose us.

"Were it not for this," says Sir John Herschel, "the eccentricity of the orbit would materially influence the transition of the seasons. The fluctuation of distance amounts to nearly one thirtieth of its mean

quantity, and consequently, the fluctuation in the sun's direct heating power to double this, or one fifteenth of the whole. Now, the perihelion of the orbit is situated at the place of the northern winter solstice; so that, were it not for the compensation we have just described, the effect would be to exaggerate the difference of summer and winter in the southern hemisphere, and to moderate it in the northern; thus producing a more violent alternation of climate in the one hemisphere, and an approach to perpetual spring in the other. As it is, however, no such inequality subsists, but an equal and impartial distribution of heat and light is accorded to both." Thus, though the seasons depend on the inclination of the earth's axis to its orbit, the influence of this inclination would be partially defeated by the eccentricity, were it not for that law of gravity, by which the velocity is increased in proportion to the decrease of the square of the distance. The one-fifteenth increase of solar heat, which, without some compensation, would seriously aggravate the sufferings of all exposed to the direct solar rays, is thus avoided by the increased angular velocity. But we have seen that the inclination of the axis of the earth's orbit is wholly arbitrary, and that it might have been even as Jupiter's, which is perpendicular to the plane of its orbit. This, would, as we have heretofore remarked, have changed en-

tirely the character of our globe. This, then, for we can arrive at no other conclusion, must have been designed originally for the important offices it performs, by the POWER that created it; and that POWER must have been intelligent and all-powerful, for no other could have foreseen the necessity of this condition and established it as a law.

A single glance at the heavens appears sufficient to establish the fact that the celestial bodies, their arrangement and movements, are the result of a well-ordered system, conceived and carried out by a self-existent CREATOR. And certainly a long continued examination and study of them does not change the first deep impression; indeed it is only the superficial observer, or he whose mind is impervious, and who delights to challenge accumulative evidence, that fails to be convinced, or asks additional proof. Nothing is wanting to fit the earth for the great offices of life. Every law essential for this purpose, whether connected with the centre of heat and light, the distant planets, or the earth itself, is stamped unalterably upon them; and not only on these, but on everything connected with them—particularly on the atmosphere—that important agent without which all else would be useless.

Plain and convincing, however, as these facts appear to us, they have not always produced the

same conviction on other minds. Men, learned in almost every branch of human knowledge, have viewed these evidences of original design in the creation, in a very different light. They saw no moving power behind the horizon that bound their vision; heard no voice within their own souls directing them to a presiding INTELLIGENCE, to whom all physical forces are obedient; felt no humility before the dread potencies which held and moved the various planetary systems in their orbits. But, for the honor of our species, there have been few only so constituted; and these have not been the greatest. It was not so with Copernicus, after years of patient but persevering industry had furnished him the data which were to establish the true system of the Universe; not so with him, when he was persecuted by a bigoted and intolerant church, and publicly ridiculed by a community whose diseases he had healed, and whose poverty he had relieved; not so when he rallied his energies in the last moment of life, to touch the immortal volume just published, before passing into a higher state of existence, to test the truth of his theory and receive the reward of his labors. It was not so with Galileo, when rich in experience and knowledge, and venerable in years, he was compelled by the same intolerant spirit to renounce a system which his enlightened conscience

approved, and succeeding ages have confirmed. Not so with Descartes, when Holland achieved a distinction in persecuting him, almost as unenviable as Italy established when she forced the venerable Galileo to bow, and disgraced herself by libelling both science and nature.

The good and the great of all ages, and all civilized countries, have recognized something more than mere physical force in the dread agencies around them. They have felt and still feel that these things had a beginning and must have an ending; but that there is that which had no beginning, and can have no ending, to whom the past and present are known, and to whose future they confidently committed spirits chastened by humility and purified by love. With such we desire to be found; for they not only excite our sympathy, but command our admiration and respect. In the eloquent language of another: "If they erred, it was in a heavenly region; if they wandered, it was in the fields of light; if they aspired, it was at all events a glorious daring; and rather than sink with infidelity into the dust, we are content to cheat ourselves with their vision of eternity. It may, indeed, be nothing but delusion, but then it was and is the delusion of the disciples of philosophy and of virtue; of men who drank deep at the fountain of human knowledge, but who dissolved not the

pearl of their salvation in the draught. We err with Bacon, the great confident of nature, fraught with all the learning of the past, and almost prescient of the future; yet too wise not to know his weakness, and too philosophic not to feel his ignorance. We err with Milton, rising on an angel's wing to heaven, and like the bird of morn, soaring out of sight, amid the music of his grateful piety. We err with Locke, whose pure philosophy only taught him to adore its source; whose warm love of genuine liberty was never chilled into rebellion with its Author. We err with Newton, whose star-like spirit shot athwart the darkness of the sphere, too soon to re-ascend to the home of his nativity."

But we need not appeal to human evidence to sustain us; nor is it necessary to cast a longing eye up to the mysterious and unknown, to interrogate the ever-active elements and forces, which answer only by the silence and grandeur of their motions. We are surrounded by witnesses, less imposing, perhaps, but not less truthful. Who has not felt the truth of these lines, while watching an autumnal sunset, when the great luminary, drawing his vestment of crimson and gold more closely around him, sunk behind the horizon; or while gazing upon the still more gorgeous and thrilling scene of an ocean sunrise, when from cloud to cloud the varied hues of light like animate

beings passed, until the deep-blue element itself seemed all on fire; or as he stood on nature's mountain-altars, looking up into the boundless infinite of noon-day, breathing an atmosphere composed of different elements, all blending in one great ocean of kindness? Who has not felt that here, even on this material globe, and within the range of human vision, enough, yea, more than sufficient existed to inspire the noblest feelings of his nature, and to lead him trembling to the throne of the ETERNAL! But what are these, all these,—the gorgeous settings and risings of the great luminary; the smiling valley or stupendous mountain; the mighty ocean with its surging billows, or the boundless fields of planetary matter,—if we do not hear them join with the immortal Galen in his hymn of praise in honor of their CREATOR? They are distinctly heard, however, by the attentive ear of Nature's votary; and it is this that arouses man from the dreamy reverie into which he so easily falls, and points his timid eye to the ALMIGHTY hand, wrapped in the radiance of its own existence, which supports the machinery of the universe, and moves the car of humanity onward.

PART III.

GEOLOGY.

I.

Turning our eyes from the brilliant heavenly orbs, which lie like jewels scattered through the depths of infinite space, to the less beautiful, but not less interesting phenomena buried in the planet we inhabit, we shall find the transition easy: for although the phenomena are different in their nature, they tend to establish the same facts; and thus reciprocally prove each other to be the work of the same designing Intelligence.

Astronomy is the elder sister, and as such, her claims to consideration were acknowledged, while Geology was struggling in the arms of inexperienced nurses; besides, the elder has everything necessary to excite the admiration and fascinate the mind, connected with it. At noon-day, the eye is involuntarily turned upwards to the great source of light and

heat, and the mind as involuntarily asks the nature of these phenomena; and while we watch the sinking orb to the limits of the rising horizon, as it fades gradually away into the bosom of the approaching night, and see the stars burst out upon the wide-spread canopy, and again hide themselves amid the light of the early morn, we can but look on with increasing interest, and a more earnest desire to comprehend the mighty and beautiful changes which mark the alternation of day and night,—and of labor and rest. But the half-hidden resources of the earth, and its deeply-buried treasures, covered with the dust of centuries—disfigured and discolored by the convulsions to which they owe their existence and locality, have been studied and developed only as the necesities of man required it. Unknown and unvalued in the earlier ages, it was not until recently that their importance was felt, and the mystery of their creation acknowledged.

Astronomy gathered strength and beauty, under the fostering care of the noble spirits to whom she had been committed; while geology was so contorted by the conflicting struggles of the Vulcanists and Neptunists, that for a long time it remained questionable whether she would survive, or if she did, whether she would not be imperfect and unnatural. But these were questions of time merely. They had

similar trials in their infancy, and had the same enemies, ignorance, and intolerant superstition, to overcome. The spirit that followed Copernicus, and Galileo, and Descartes, found the venerable Buffon in the middle of the eighteenth century, and left him not, until he abandoned everything in his book respecting the foundation of the earth, and generally, all which was contrary to the Mosaic Cosmogony.

But these sister sciences have been equally triumphant; and now from the vantage ground of a sure foundation, they unite their testimony to explain each other. And while they point out the sources of comfort and happiness so richly provided for mankind, they also silently but eloquently urge him to a higher and purer faith, and a deeper and holier adoration. It was not, however, until recently, that geology contributed to this end. Want of knowledge, and a fear of unsettling the foundations of the Christian religion, kept her votaries trembling over conflicting theories, some of which are yet unsettled. But sufficient is now known to warrant the most satisfactory conclusions, and to justify the following reflections, which we offer in connection with the other sciences, in order to exhibit the harmony and beauty of the mighty chain of arrangement and adaptation which encircles the universe.

Each successive era of discovery in this science, gave

birth to its own theory of creation; which continued with more or less popularity, until a new theory, based upon new discoveries, succeeded it. In the course of these changes, and after the fossil history of the earth had been partially studied, the theory of a gradual subsidence of our globe and the development of vegetable and animal life, was advanced by various speculative minds. The grandeur of the changes which this theory presented for contemplation; and the excitement and pleasure which the hope of unlocking the crypts of the primeval world, and reading the mysterious story of past centuries and extinct genera, afforded the student and the philosopher; and the fact that the Nebular Hypothesis, so strongly supported by astronomical observation, agreed perfectly with this theory, gave it a wider circulation and greater interest than any of the preceding. Indeed, the magnitude of the subjects contemplated, and their important connection with the origin and destiny of mankind, were in themselves quite sufficient to excite the philosophic and Christian world.

The boldness of the speculations which followed this theory, or rather grew out of it, has no parallel in the history of the human mind. The evidences on which it was based, were not only weak and unsatisfactory, but of a most doubtful and conflicting char-

acter; depending chiefly upon the bungling interpretation of a witness whose language was imperfectly understood; and whose signification was improperly rendered, by ignorant or designing officials. Yet, the records of the Evangelist and the truths of revelation, written on stone by the hand of the ALMIGHTY, amid the thunders of Sinai—attested by a long line of miracles performed and prophecies fulfilled, and sealed with fire from heaven, were set aside as the idle dream of some ingenious impostor, to whose mind the past, the present, and the future, were dimly visible. But such is the disposition of human nature,—the doubtful, the mysterious, and the unknown, excite more interest, and too frequently more faith, than those real and tangible things by which we are surrounded; or such even as are inwrought with our existence. It is this, that unfixes the mind,—that gives it a wandering, unsettled character,—that fascinates it with the imaginary colors of revery and dreams; unfits it for the necessary efforts and iron tasks of usefulness; that supplants the real with the imaginary, and finally robs it of the only genuine source of happiness, faith in the protecting care of an ever-present and merciful Providence, during this life, and of a hereafter, compared with which, the beauties and blessings of the present, are but faint reflections. To such, life is unreal and

empty; a wild, uncultivated sand-desert, uncheered by fountain, or flower, or harvest-field. They have no true conception of its obligations and duties, and without making any good and lasting impression on the world without, or receiving any on the soul within, they die and are forgotten. Forgotten—by the world only, not by all; one day at least, and by one person, will they be remembered, when the talents received are by the MASTER demanded with usury. The history of that day is already written; to it we refer the listless wanderer, as we would the weather-beaten bark to a port, for safety.

The development hypothesis, to which we have referred as the last fruit of speculative daring, finds its chief support in the records of geology. The living world presents little, if anything, to warrant such a belief; but the evidences gathered from the fossil history of extinct species, before the mighty pages of the earth were fully unsealed, seemed to authorize much that was advanced. There was nothing, however, at any period of geological progress, that could be construed by a reasonable and just method, into the support of the development hypothesis, and the atheistical ideas to which it gave birth. But, in order the more perfectly to comprehend our subject, we will give a brief statement

of the theory, and of the phenomena on which it was based, before we examine the argument, or refer to subsequent and more satisfactory discoveries.

II.

THE DEVELOPMENT THEORY.

M. Geoffrey St. Hillaire, contended that the existing species sprang from the extinct forms; and it is farther insisted, that the history of the change or transmutation is found registered in the rock record of the past. This idea was not without supporters of large and varied experience. Lamarck was among them, and not the least important. While laboring to distinguish the various genera and species, he found that they constantly ran into each other; or were separated, if at all, by lines too indistinct to be discovered. He also found great disparity between those which he knew must have descended from the same stock. These facts contributed to induce him to advocate the theory of transmutation. But it was not these things alone which induced that opinion; other phenomena contributed to the result. He was also influenced by the change produced in various vegetables, by cultivation, climate, locality, &c., and the fact that they transmitted their newly-acquired

character, by which means a new plant or species was introduced into the kingdom; and also, by the change effected on birds, fowls, wolves, horses, &c., by domestication.

He contended, that every change in the circumstances by which animals were surrounded, created new desires, which resulted in a change of habits. These caused changes in their physical structure, which, in order to accommodate itself to the new circumstances, took additional organs and varied forms. Organs useless, by reason of the change, gradually wasted away; and others, better adapted to the new conditions of life, were developed by the force of necessity. Thus, by degrees, the whole physical structure was remodelled. Having assumed the fact, that external circumstances may cause a change in the organs, he proceeded to point out instances of a supposed change. Otters, beavers, &c., he contended were not originally created web-footed; but, that as their wants led them to the water in search of food, they stretched out their toes to swim, until, by continued efforts, the skin at the base of the toes became elastic, and finally grew into the broad membrane which now so admirably fits them for the water.

Fear, and a desire to escape from the carnivora which fed upon the antelope and gazelle, had the effect of remodelling their forms; changing the dif-

ferent and less graceful limbs into such as now distinguish those beautiful animals. The nature of the country and foliage, drew out the neck of the cameleopard, and prepared it for its native land, the interior of Africa. These were some of the starting points for the transmutation theory.

The discoveries in geology opened up a new field for conjecture. In its early stages or history, it appeared to support the theory of Lamarck and his predecessors. It was said, and with some truth at the time, that the earliest fossils were of the simplest forms of organic life; and that each succeeding strata of the earth's crust exhibited higher and higher organisms. Thus, becoming more and more perfect, until the tertiary period crowned the list with man; the present ruling monarch, at once the highest organism and noblest specimen of created matter.

These cosmogonists, take the material globe, formed and fashioned out of the nebulous matter, under the influences referred to in our chapter on that subject, immediately after it takes its place in the family of worlds; and covering it with its crystalline coat of rocks of irregular thickness, invest it with power, independent of all other agencies, to cover its rugged surface with the vegetable variety which adorns it—the rivers which gladden it with their music, and refresh it with their moisture—and the countless

tenantry, which quicken it with the stir and bustle of life, and mark its strata with their bones. They commence with the crystalline rocks, which they call the "bases rocks." Next to these follow the stratified rocks, which appear to have been thrown up out of their original positions, and frequently rent asunder by some internal force. These rents are again filled up by crystalline matter resembling the great primitive bed; which must have been forced up while in a state of fusion. "Thus," says one of these cosmogonists, "there is first a great inferior mass composed of crystalline rock, and probably resting immediately on the fused and expanded matter of the interior; next, layers or strata of aqueous origin; next, irregular masses of melted inferior rock, that have been sent up volcanically and confusedly at various times amongst the aqueous rocks, breaking up these masses, and tossing them out of their original levels." From these facts they presumed that the crystalline rocks, of which granite is the type, is the condition into which the solids of the earth were agglomerated.

These rocks contain no organic remains—no fossil hieroglyphics for the learned to decipher, or the curious to admire. A solid strata of variable thickness, enclosing the igneous agencies of our globe, and bearing on its surface the accumulated deposit

of unnumbered centuries. The dividing line between potencies which communicate with the external elements, through the mouth of the crater—the rising and sinking of islands and continents, and the convulsive movements of the earth itself, by which their history has been written and their power attested; and the outward elements, so beautifully combined for the purposes of good—so harmoniously blending and co-operating together in their reciprocal and indispensable office, that the varied and necessary changes are effected without deranging the laws of vegetable and animal life. Day and night, winter and summer, seedtime and harvest, are all welcomed in their turn; each making the other more desirable, and all contributing to the gross sum of human happiness. The fertile valley offers up its treasure, even under the shadow of the burning volcano. The fearful chasm of the earthquake, is filled by vegetable and detached mineral matter, and covered with the ivy and the vine; while the bald surface of the newborn island is clothed with flowers and evergreens.

Such is the contrast between the internal and external elements of our globe. A contrast which meets us at every turn we take in the innumerable and diversified walks of nature. But it is too frequently unseen, and seldom, if ever, fully appreciated. The harvests of fruits and grains, have their annual return

celebrated by many a well-measured line; but the combining elements, and changing solar rays, by which this well-appointed plenty is secured, are seldom seen even by the eye which their labor brightens. This, however wrong in appearance, may yet be right. The great eternal AUTHOR lifts the mind up to the contemplation of Himself by other means, and deems it best.

Next, in the ascending steps of these theorists, the Grauwacké, or Silurian system is interrogated. This system rests generally on the primary bed, but in some cases directly on the granite. Here the transmutationists find the first evidences of organic remains; sea-plants, corals, and shell-fish; the humblest divisions of the vegetable and animal kingdoms. The radiata, articulata, and mollusca, were, according to their report, represented by their simplest forms; while the higher and more perfect divisions were wholly wanting. Ascending to the next strata, they found the fossils more abundant; in which, the trilobites, various genera of mollusks, gasteropoda, and cephalopoda, make their appearance. First, the lowest orders of the mollusks, then a higher order, and continuing to advance until the highest is reached Establishing, even in these early records, the progres sive tendency of organic matter. Next in the scale, and a little above the Llandielo rocks, certain annelides

or sea-worms were found. They were red-blooded, and it was supposed that they formed a link of connection between the white-blooded worms, and the humblest classes of the vertebrata.

Passing into the Ludlow rocks they found the remains of "six genera of fishes of obscure character," and afterwards the remains of minute fishes discovered in the Amystry limestone, by Mr. Phillips. Thus, the friends of the theory, are encouraged as they ascend in the strata of the earth. The various witnesses appear to confirm each other. There is no conflict of testimony notwithstanding the multiplicity and variety of the sources from which it is drawn, and the utter impossibility of conference and prior agreement between the witnesses.

Ascending, they find themselves next in the Old Red Sandstone or Devonian group, where they find an increase of fossil fishes. The silurian forms continue, but they show a decrease. The fishes in this system are not, according to the theory, of the highest order, although they show signs of advancement. "The predominating fishes of this system and the only ones which existed for some ages," says an advocate of this theory, "are arranged by M. Agassiz, in two orders, with regard to their external covering, which that naturalist holds to be, in fishes, a reflection of the internal organization. Both, it is to be re-

marked at the very first, are manifestly of an inferior character to the two other orders which afterwards came into existence, and still are the principal fishes of our seas, these being covered by true scales, and respectively named Ctenoid and Cycloid, from the forms of that part of their organization. The two orders of early fish are covered with integuments considerably different in character; the one (*placoids*) with irregular enamelled plates, the other (*ganoids*) with regular enamelled scales, the first being not placed over each other, as scales are, but laid edge to edge, in the manner of a pavement. These characters, according to M. Agassiz, were accompanied by a rudimentary or cartilaginous skeleton, while the Ctenoids and Cycloids possess an Osseous structure."

"Of certain of the ganoids, it is remarked by every geologist, how much they approximate to the form and armature of the crustaceans, an order of the next lower department of the animal kingdom."

"The cephalaspis may be considered as making the smallest advance from the crustacean character; it very much resembles in form the asaphus of lower formations, having a longish tail-like body inserted within the crust of a large crescent-shaped head, somewhat like a saddler's cutting-knife. The body is covered with strong plates of bone, enamelled, and the head is protected on the upper side with one

large plate as with a buckler—hence the name, implying buckler-head. A range of small fins conveys the idea of its having been as weak in motion as it was strong in structure."

We cannot admit that this argument is a good one, even if they had the basis for it; but this they have not. These positions are assumed ones; and the authority which they presume to quote is grossly abused. But, we leave it for facts hereafter stated to contradict. Up to this period, their light was uncheered by land plants, from which, with their characteristic readiness, they inferred that there was no dry land in this era of the world's history. But, happily for them and us, this state of things could not always continue. Change is written upon all things, and not less certainly on systems which require centuries to effect it. The elements were at work, and in due time the Grampians, Alps, Appennines, Pyrenees, and Carpathians, emerged from the wide extended ocean. Thus commenced the era of dry land, and with it, a new order of things.

The carboniferous formation, with which they date the earliest dry land, is one of great interest, not only to the theorist, but to the world. It is appreciated by all classes, and all ages; the rich and the poor,—the ignorant son of idleness, the child of poverty, and the profound philosopher. But, at present we are to

consider the part this group is forced to perform in the theory of Development, and not the ten thousand uses to which its coal-beds are put, and the innumerable blessings resulting from that well-appointed provision for the benefit and happiness of mankind.

The advocates of Development linger long with this formation; indeed, it may be called their favorite one. It is composed chiefly of limestone formed in different ways: first, by the accumulation of carbonate of lime in the bottom of deep seas, which is afterwards conglomerated by volcanic action; secondly, by the coral deposits; and thirdly, such as are composed almost entirely of marine shells. From the immense coal-beds, found in this formation, these *inferential* gentlemen *infer* that the vegetable kingdom predominated; and that it was more luxuriant than at any preceding or subsequent period of the earth's history. But, notwithstanding the luxuriance of that FLORA, they contend that it was composed entirely of gigantic shrubs, at present but partially represented. "Two-thirds of the plants of the carboniferous era are of the cellular or cryptogamic kind." Thus they attempt to prove that the earth's FLORA, as well as its FAUNA, commenced with the humblest characters; the flowerless lichens, mosses, ferns, &c. Associated with these they found the lepidodendra, now extinct, whose internal structure

induced them to believe that they were a kind of link between the singel-lobed and double-lobed plants.

In conclusion, the author from whom we have quoted, says: "such was the vegetation of the carboniferous era, composed of forms at the bottom of the botanical scale, flowerless, fruitless, but luxuriant and abundant beyond what the most favored spots on earth can now show. The rigidity of the leaves of its plants, and the absence of fleshy fruits and farinaceous seeds, unfitted it to afford nutriment to animals; and, monotonous in its forms, and destitute of brilliant coloring, its sward probably unenlivened by any of the smaller flowering herbs, its shades uncheered by the hum of insects, or the music of birds, it must have been a sombre scene to human visitants. But, neither man nor any other animal was then in existence to look for such uses or such beauties in this vegetation."

Although this school of speculative philosophers admit that the fishes of the carboniferous era made advances to the lizard character, yet they think no land animal made its appearance until after that era had passed away; and the atmosphere had been prepared for terrestial zoology, by some chemical process, by which the superabundant carbonic acid gas was taken up and deposited in the limestones of that formation.

The absence, or apparent absence, of land animals in that era, induced the belief that the atmosphere was not adapted to air-breathing animals. To prove this hypothesis, reference has been made to Sir Henry De la Beche's estimate of the quantity of carbonic acid gas locked up in limestone. According to his calculation, each cubic yard of limestone contains 10,000 cubic feet of carbonic acid gas. This gas was known to be injurious to animal life, while it was believed that vegetables could flourish in an atmosphere containing much more than exists in the present combination. From these evidences it was easy to infer, that before and during the progress of the carboniferous formation, the atmosphere was unfit, from the superabundance of that gas, for the existence of air-breathing animals; and, that it was not until after the carbonic acid gas of that period had been imprisoned in the limestone, that terrestrial zoology commenced. "There can be little doubt," they wrote, "that the infusion of a large dose of this gas into the atmosphere at the present day would be attended by precisely the same circumstances as in the time of the carboniferous formation. Land animal life would not have a place on earth; vegetation would be enormous; and coal strata would be formed from the vast accumulation of woody matter, which would gather in every sea, near the mouths of

great rivers. On the exhaustion of the superabundance of carbonic acid gas, the coal formation would cease, and the earth might again become a suitable theatre of being for land animals."

We will see hereafter how perfectly ridiculous this argument is; and how wholly it is based on assumptions. It will be found that large quantities of vegetable matter are now gathering "in every sea, at the mouths of great rivers," and that coal-beds are now in the process of formation, and ever have been; and that future generations will find the same evidences, and will be equally warranted in coming to a similar opinion regarding this era. But, it will not be forgotten that we are now giving the theory and the evidences on which it was based.

In following these friends of development, we next find ourselves in the era of the NEW RED SANDSTONE, with which they date the beginning of terrestrial zoology. The second group of this series, is a limestone with an infusion of magnesia, in which, "zoophytes, conchifera, and a few tribes of fishes," appear, "with faint traces of land plants; and a new and startling appearance, a reptile of Saurian (lizard) character." Next to this group is the muschelkalk, noted for the specimens of land animals, which the friends of development considered first in the fossil record. "They are of the vertebrate sub-kingdom,

but of its lowest class, next after fishes—namely, reptiles," with imperfect respirator organs, allied to the crocodile and lizard tribes of the present day. Here also, are found ripple-marks, made by the receding tide, and perpetuated by the hardening of the stone; and foot-marks of various land animals, and finally at Runçon, near Manchester, and in other localities, the tracks of an animal *supposed* to have had the body of a reptile, and the beak and feet of a bird, "which had been *a link* between these two classes." The next step brings you to the Oolite, where you are introduced to the first, and as these theorists always begin the departments, to the lowest order of mammalia. Thus, step by step, you are carried along by this theory, through the various grades of organic matter. Entering the lowest and most imperfect orders and families, they pass regularly through all the intermediate divisions to the upper geological groups, where the highest and most perfect types of vegetable and animal life appear. Strange and beautiful, yet, imperfect and dangerous theory; how many noble minds have stumbled over thee into the unknown future! Wise in every thing but the one great essential—in that foolish.

Enough has been said of the theory, to enable the general reader to comprehend the force of the entire argument; and without following it through the suc-

ceeding strata of the earth's crust, we will proceed to notice new discoveries which contradict the evidences on which the theory rests. And as we have followed the friends of development up through the various strata, beginning at the Silurian system, we will again return to that system; and again follow the strata up in the same order. In this second journey, or new reading of the fossil record, we will follow the interpretation of Sir Charles Lyell, Hugh Miller, Prof. Agassiz, and others of like distinction. In their edition of the fossil history of our globe, all the recent discoveries are carefully noted. If the reader will go with us, we will compare the theory of development with this edition, and thus learn, if possible, how far they agree with each other.

III.

THE TRUE POSITION OF THE FOSSIL REMAINS.

Sir Charles Lyell divides the Silurian system into two parts; known as the upper and lower Silurian groups. These are again divided into the Wenlock and Ludlow formations in the upper; and the Llandeilo and Caradoc formations, in the lower Silurian group. These formations are found in the following

order—first and lowest, the Llandeilo; secondly, the Caradoc; thirdly, the Wenlock, and last and uppermost, the Ludlow. At the base of the Silurian system, a dark-colored micacious grit is formed, which is now known as the "Llandeilo flags." This formation contains large quantities of *trilobites*, *graptolites*, *lingula* and *crystidiæ*. Of these the trilobite are the most interesting. They were extraordinary in their formation, and certainly, judging from the perfection of their eyes and other parts, they were not low in their order. The same genera are found in these several divisions; with an increase of shells as you ascend. And as early as 1839, it was known that fossil fishes were to be found in the Ludlow group. Thus stood the fossil history of that system for many years; but now it is entirely changed. Recent discoveries have invested this group with infinitely more interest.

In 1838, Sir Roderick Murchison found the *Onchus Murchisoni*, and *Onchus tennistriatus*, the highest order of placoids, in the Llandeilo flags. This was the commencement of a series of discoveries in that system, both interesting and important. In 1842, Mr. Phillips found "innumerable small teeth and spines," just above the Aymestry limestone; and in 1845, "a portion of a fish belonging to the cestaciont family of the placoid order," was found in the Wen-

lock limestone. While these discoveries were being made in the old continent, the geologists of this country were busily engaged in the same field. "A defensive spine of a placoid was found in the Onondaga limestone of New York," which occurs near the base of the upper Silurian system. But, before this last discovery, Mr. Hall, of the States' survey, found a fish-bone in the Oriskany limestone, which is much lower than the Onondaga limestone. In 1847, "defensive spines of fishes" were found in the Upper Llandeilo flag, by Sir Roderick Murchison: and afterwards similar spines were found in the Bala limestone by the Government Survey. The Bala limestone is below the Lower Silurian group, in the Cambrian or older fossiliferous rocks. The Onchus, above referred to, has been found in both the Upper Ludlow rocks, and the Bala limestone; yet they are separated from each other by thousands of feet, and must have required centuries for the deposit of the strata between them. The *Onchus*, however, is as perfect in the Bala limestone, as it is in the Ludlow rocks. Prof. Agassiz found on comparison, that the *spine* of the Onchus which was found is more than twice as large as the *spine* of the dog-fish; or that even of the Port Jackson shark. These early placoids were found to be larger than those of the present day. They were not mere abortions or pigmies, but

true and noble vertebrata, of enormous proportions, armed with defensive spines, five times as large as the dog-fish of the present era; Adams at their birth, admitting of no improvement, and proving by comparison that none has ever taken place.

So much for the Cambrian and Silurian systems, in which the friends of development found nothing but trilobites, mollusk, gasteropoda, and cephalopoda. It is true, they found annelides, the supposed link between the white-blooded worms and the humblest classes of vertebrata; and a little higher up in the Ludlow rocks, they found a few very "small fishes of obscure character." It is well for the friends of development, that the *Onchus* and the other placoids of that era of the world's history, are now unable to use their defensive spines, and that all redress for slander is "barred by the limitation of time." In either case they might suffer the just penalty of their wilful ignorance and malicious misrepresentations. It is now well settled, by authority of the highest character, that the placoids of the Silurian and Cambrian systems belong to the most perfect type of that division of the vertebrata. Professors Agassiz, Owen, and Sedgwick, Sir Phillip Egerton, and James Wilson, all agree in assigning them the highest position. Their osseous skeletons, defensive spines, mouths, and brain, most clearly establish their

claims, and prove that they were not "fishes of obscure character," but that they were representatives of the highest types of their class.

IV.

OLD RED SANDSTONE.

In the Old Red Sandstone, the friends of development found a few fishes, but "they were manifestly of an inferior character to those which succeeded them." These manifestly inferior fishes were no other than the ganoids and placoids of the Silurian and Cambrian systems. They reported them as inferior, with nothing but "a rudimental or cartilaginous skeleton;" and approximating very nearly to the "form and armature of the crustaceons, an order of the next lower department of the animal kingdom." This is a mistake; for the placoids had a real osseous skeleton, and other marks which induced the best naturalists and physiologists to place them among the most perfect of their order; and superior to their kindred of the present day. But a more recent and thorough examination of the lower old red sandstone, has introduced other fishes of that system, equally interesting. If the fishes first discovered in that era were of low order, and imperfect

structure, recent discoveries prove that it was not owing to the strata in which they were imbedded, or the age of the world in which they flourished and decayed. Without attempting a further defence of of the much-abused placoids of the Silurian and Cambrian systems, we will at once present the *defensive spine*, and other armor of the ASTEROLOPIS, a native of the Old Red Sandstone.

V.

ASTEROLOPIS.

For our knowledge of this extraordinary fish, we are indebted to Hugh Miller; one of the most thorough and successful geologists of the present day. His own career and enterprise, as interesting as the extraordinary fish which he has so fully described and illustrated; and his fame as enduring as the fossils he has torn out of the strong leaves of the Orkneys; or Stromness, which he has immortalized. In speaking of the Orkneys, he says; "It is not too much to affirm, that in the comparatively small portion which this cluster of islands contains of the *third* part of a system regarded only a few years ago as the least fossiliferous in the geological scale, there are more fossil fishes enclosed than in every

other geologic system in England, Scotland, and Wales, from the coal measure to the chalk inclusive." But of all this ichthyic collection, the *Asterolopis* is the most interesting. Various parts of its skeleton were found in the "three-barred pyramid of Stromness," in 1848, by Mr. Miller, and in Cornwall in 1850, by Mr. Peach.

The first "well-marked bone," noticed by Hugh Miller, resembled a roofing-nail, about seven inches long. This length indicated a fish of enormous proportions. It was an object of much interest; and the more so to Mr. Miller; for previously in his work on the "Old Red Sandstone," he had represented that system as an age of dwarfs at the beginning, terminating at the top, with an age of giants. But he now for the first time discovered his error. Here, at the very base of that system, the remains of a fish of colossal proportions, greater than any he had before denominated giants, are formed, showing the danger of hasty conclusions based on limited observation. It is well for science that we have such men as Hugh Miller; men with moral courage to correct an error whenever detected, regardless of theories or opinions; who seek truth and truth only, and as fearlessly declare it. As long as the discoveries of science are transmitted to the public through such mediums, there need be no apprehension of impo

sition and wrong. Such men are the true representatives of their age; and heaven seems to have fitted them for their high and responsible offices.

We have selected the Asterolopis. or star-scale, so called from its star-like markings, because it has been more fully examined, and is, perhaps, the best representative of its order. But let us first inquire into the grand divisions of the animal kingdom; which we will find divided into four great departments; and these again into classes, which are divided into orders; and these are again divided into families, &c., &c. The first department, that of the vertebrates, is divided into four classes; first, Mammalia; second, Birds; third, Reptiles; and fourth, Fishes. The class of fishes is divided into the ganoids, the first order; having large, bony, enamelled scales, and osseous skeletons; secondly, the placoids; thirdly, ctenoids; and, fourthly, cycloids. It will be seen on examination, that these orders are each distinctly marked by peculiarities, which enable the naturalist to arrange the exhumed remains without any difficulty. The Asterolopis has all the marks of the ganoid, and is therefore placed in that order. It is in the highest order of its class, and we think it is entitled to the highest place in its order. But what are the facts on which this opinion is based.

The Asterolopis was covered with true osseous scales, and well supplied with free and protected gills. Its head was covered with an osseous plate, which constituted a Cranial buckler, in some cases large enough for a shield. The nail-like bone found by Mr. Miller, measured five and a half inches, and must have belonged to a buckler more than eighteen inches in length; and it is believed that the Asterolopis to which it belonged was at least nine feet long. These are the conclusions at which Mr. Miller arrives, after much and patient investigation. Other Cranial Bucklers show that still larger ganoids existed during that period. Fish at least twelve feet long, with all the marks of their high order. "Thus," says Hugh Miller, "in the not unimportant circumstance of size, the most ancient Ganoids yet known, instead of taking their places agreeably to the demands of the development hypothesis, among the sprats, stickle-backs, and minnows of their class, took their place among its huge basking sharks, gigantic sturgeons, and bulky sword-fishes. They were giants, not dwarfs." Again, the same author says:—"In Cranial bucklers in which the average thickness of the plates does not exceed three *eighth* parts of an inch, their thickness in the centre of the ridges must have been three *quarters*. The head of the largest crocodile of the existing period is defended by an armature greatly less strong

than that worn by the Asterolopis of the Lower Old Red Sandstone. Why this ancient Ganoid should have been so ponderously helmed we can but doubtfully guess; we only know, that when nature arms her soldiery, there are assailants to be resisted and a state of war to be maintained."

The Asterolopis was supplied with sharp teeth, and powerful jaws with two sharp cutting edges; thus approaching the character of the reptile. This reptilian cast, together with the twisted or spiral coprolites found so abundantly, induced the belief that it was carnivorous in its habits. Many other bones belonging to different parts of the Asterolopis, have been found; such as the maxillary bone, the hyoid bone; the coracoid and dermal bones; the Ischium, Rays, and *internal* bones of various forms and sizes. These prove the osseous character of its skeleton beyond a doubt. It was at first inferred from the supposed covering or scales of the Asterolopis, that these early Ganoids had cartilaginous, and not osseous skeletons, and therefore, of an inferior order.

The learned Prof. Agassiz is quoted as authority for this position, but we think very unjustly. This we assert has not been the opinion of any eminent naturalist since the discovery of the specimens alluded to. "This fish," to speak in the technical language of Agassiz, "undoubtedly belongs to the Cestracion

family of the Placoid order,—proving to demonstration that the oldest known fossil fish belongs to the highest type of that division of the vertebrata." This was the language held by a learned reviewer, when speaking of the Asterolopis. Certainly, if it was the highest type of its division, it had *not* a cartilagenous skeleton; but on this point there appears to be no dispute at present. Instead of approximating to the form and armature of the crustacians, as the development theory required, their whole structure indicated an approximation rather to the reptile.

But as Mr. Miller very justly remarks, rank depends on *brain* and not *bone*. If *bone*, indeed, was the evidence of advancement, the animals of the present era would prove to be below and not above their ancient or early progenitors; for there are none which will bear a comparison in size or osseous structure to the huge monsters of the tertiary period. By this standard man himself would dwindle down into a secondary position. This is not true, however; it is the brain that distinguishes the true superiority; and it is by this that development should be measured and orders arranged. By this standard, which undoubtedly is the only true one, the Placoids and Ganoids of the Lower Silurian and Cambrian, and the Old Red Sandstone systems, take their places high up in the scale of ichthyic existence. Not at

the foot of the list of fishes, but at the head; real giants, constituting the highest and best specimens in their order.

Before leaving this system we must beg our readers to remember that we have not referred to all the witnesses of this vast field. The Asterolopis is not the only large and well developed fish whose history has been written on the rock-book of that era. There are many, to use the language of Mr. Miller, this series "could supply with ichthyolites, by the ton and the ship load the museums of the world." A few only, of the many witnesses, have been interrogated, but these, we think, fully contradict the idea of Development.

But, these fish, however perfect, are not the only vertebrata of this group. In 1849, "a double row of impressions, bearing a considerable analogy to the European cheirotherium, was announced as having been detected by Mr. Isaac Lea, in the Old Red Sandstone at Pottsville, near Philadelphia, in the gorge of the Alleghany hills, where the Schuylkill breaks through the Sharp Mountain. These foot-prints occur on a ripple-marked sandstone, and are each about four inches long, and four broad. The animal appears to have had five toes, some of which exhibit unguinal appendages. The geological position of the bed is well determined, and the overlying

coal formation contains the usual characteristic plants." Such is Sir Charles Lyell's report of the reptilian foot-marks of that era, based on the authority of the ninth volume, January number, 1850,—of the Scientific Journal of our distinguished fellow-citizen, Prof. B. Silliman. Thus, at this late period it is first ascertained that air-breathing animals,—that reptilian monsters, began their existence at and before that early period of the world's history.

The discovery of these foot-marks was considered of the greatest importance. So much so, that Prof. H. D. Rogers at once proceeded to the place where they were found, in order to gratify himself by a personal inspection. He concluded after much examination, that they were not in the Old Red Sandstone system, but in the lowest part of the coal formation, or carboniferous system. On this point, therefore, there is some contrariety of opinion. But if these foot-marks are not in the Old Red Sandstone, there can be no doubt that they exist in the dividing strata of the two systems, and ages before the great mass of the carboniferous group was deposited.

VI.

CARBONIFEROUS ERA.

In our remarks on this group, we shall be governed almost entirely by Sir Charles Lyell; than whom, no man is more reliable. In treating of this series, he observes the divisions usually made by geologists: "1st. That known as the coal-measure, of mixed fresh water, terrestrial, and marine origin. 2d. That which in England is called the mountain or Carboniferous limestone, of purely marine origin, containing corals, shells, fishes, &c." These divisions are not only different in their origin, but as a consequence, they are also different in their fossil history. By referring to our preceding synopsis of the reading of this formation, by the friends of development, it will be seen that they failed to find any thing more advanced than vegetables of the simplest character; and the lower genera of crustaceans and mollusks.

Over five hundred species of plants have been found in this group. Of these, the ferns are most like existing species. But, although many of the carboniferous plants, indeed, a large majority, are now extinct, they have left a perpetual record of their size and character. The botanical families are all

represented, from the Cryptogamic or lowest, to the highest in the vegetable kingdom. The *Sigillaria*, are among the most interesting forms. About thirty-five species of this genus have been found. They grow to an enormous size. Some of the fossil trunks measure between sixty and seventy feet in length; and from one to five feet in diameter; while their fossil roots prove that they must have spread in the earth from sixteen to twenty feet. These certainly were not pigmies. Their size and texture unite to show that they belonged to the highest and best developed family of the first order. Five genera of Dicotyledons; embracing Pines, Firs, &c., have also been found; and last, but not least important, several families of Monocotyledons, have been found associated with their more humble relatives.

Thus it is seen, that this era was not without flowers and fruits, and farinaceous seeds. Most of the Monocotyledons which have been found, were fruit-bearing trees. The forests of that early period must have been abundantly supplied with fruits and fragrant with flowers; nor could it have been without the hum of insects, and the music of birds. It contains evidences almost beyond the possibility of doubt, that its wild and luxuriant woodlands were redolent with the blossoms of productive vegetation; and vocal with the music of a well-appointed choir. It

is possible that man did not then exist; but the little feathered songster sung no less sweetly. The morning breeze caught up its grateful notes and bore them to a holier ear than his. In the unbroken quiet of those sylvan solitudes, there may have been no thinking, rejoicing, or sorrowing human heart, with the quick throbbings of anguish or delight; yet in nature's great cathedral, God's humbler creatures offered up their low perpetual hymn.

"True exogenous trees existed in great numbers and of vast size," says Hugh Miller, after having examined the coal-fields with the greatest care. In speaking of the Dalkeith and Falkirk coal-fields, he says: "I can scarce take up a piece of coal from beside my study-fire, without detecting in it fragments of carbonized wood, which almost always exhibit the characteristic longitudinal fibres, and not unfrequently the medullary rays." Among the fossils of this group large araucarians and pines are abundant. But, below this system, ferns have been found. A fine specimen found in the lower old Red Sandstone, is figured by Hugh Miller, in his "Footprints;" with another fossil lignite, belonging to the same system, which bears all the marks of a true Dicotyledonous plant. In many localities marine plants only are found, but this is not at all wonderful. It will be recollected that the carboniferous era is

divided into what are called fresh water and marine formations. In the fresh-water division, land plants are found belonging to almost every family; but in the marine division the higher orders are not found, and the reason is obvious.

This difference is natural, and depends upon the locality, and not upon the relative ages of the vegetable groups. The same distinctions exist at the present time. The sea has its lichens, mosses, &c., and the dry land has its pines, oaks, &c. In some of the south-eastern counties of England, there are, first, a layer of marine origin, with all the fossils belonging to such a formation; next above, there are three fresh-water formations; each bearing the fossil marks of their origin; and then above these there is another marine formation, with fossils similar to those in its kindred strata far down below. This arrangement very clearly illustrates the cause of the difference between the fossils in the two divisions of the carboniferous group.

But this, it will be remembered, is precisely the position assumed by the friends of development. They contend that the surface of our planet was, in an early period, covered with water or an ocean; and that that period is marked by the humblest types of vegetable life. This state of the vegetable world continued until dry-land appeared, when terrestrial

or land plants first made their appearance. If this were admitted as a fact, it would not prove a transmutation of species, but only that land vegetation, which is entirely different from marine, did not exist in the ocean or in the marine era. They are different in their organization, distinct in their character, and therefore require different and distinct conditions for their development or growth. This was then, is now, and always must be true.

The preponderance of certain families proves that they resisted the changes to which they were exposed better than other families which passed away without leaving any fossil record. The resisting power of vegetables is different in different families. This was proved by experiment made by Dr. Lindley. He threw one hundred and seventy plants into a vessel containing fresh water. This number included or embraced all the families of which the coal measures seem to consist, and some others which might be supposed to have co-existed with them. In the course of two years one hundred and twenty-one species had disappeared, having entirely decomposed. Of those which remained, the most perfect were species of the *coniferæ*, ferns, palms, *Sycopodiaceæ*, and their kindred of similar character. These, it will not be forgotten, are analogous to the plants of the coal measures. It appears from this, that the

vegetables composing the great body of the coal formations, are such, as were able longest to resist the decomposing agencies. Other families existed, but they passed away without leaving any registry of their growth and decay. In this way the predominance of families may be accounted for. But there may have been other causes for it. That the coal-beds were formed from a deposit of accumulated vegetable matter at the mouths of rivers and in estuaries, there can be no doubt. In this way large quantities of vegetable matter are now annually deposited at the mouths of our rivers, where they are covered up with sand and mud, thus forming regular layers.

The banks of the Mississippi and of almost all its contributaries, are lined with what the citizens call "cotton-wood." This tree is one of very rapid growth, confined chiefly to low and wet places. Every change of the stream or bed of the river, and these changes are frequent in southern rivers, necessarily sweeps away a larger or smaller quantity of these trees. These are carried down to the mouth of the great outlet, and there deposited together. In this process other trees are collected and deposited, but the great body of the future coal-bed, is necessarily composed of "cotton-wood." If in the far-off future this bed is turned up for the accommodation and

comfort of man, either gradually or by some sudden violence, it may then be inferred from the predominance of "cotton-wood," that that family was the ruling one of the present era; and that the atmosphere was especially adapted to the growth of that tree; whereas, in fact, it is an insignificant tree, confined almost entirely to the sand-banks and newly made deposits, on the shores of the rivers in the southern section of our country.

It may also be inferred from the immense deposit of vegetable matter, that this era was one in which the vegetable creation predominated; just as it is now inferred from the coal beds, formed in the same manner, that the era of their formation was uncheered by terrestrial zoology. And if there should be large quantities of limestone found in that formation, as there is now in the coal era, it will also be inferred, that the great abundance of vegetable matter resulted from the peculiar constitution of the atmosphere, which favored vegetable, but retarded animal development; unless they should be fortunate enough to discover the human remains in the limestone which is now in the process of formation on the northwest coast of Gaudaloupe, at St. Domingo, and other localities in the West Indian Archipelago. A discovery of that kind would destroy the theory, just as the discovery of fossil reptiles and birds in the

carboniferous era, has destroyed similar arguments and speculations, concerning it. Hereafter it may be inferred, from the human remains found in the limestone, of which we have spoken, that this era was best adapted to the development of man; while the vast deposit of vegetable matter in the Mississippi, and other places, will lead to an opinion directly opposite. These contradictions, however, will not be greater than the contradictions, found in and based upon, the carboniferous era.

It must be borne in mind, that the entire fossil history of the earth's crust is not known. A few detached leaves only have been torn out of the vast book; and these are as yet but imperfectly translated; the remainder is sealed even to the eye of science. Every advancing step of the geologist, and each succeeding stroke of the pickaxe, brings some new fossil to light. Appearances and evidences which warranted an opinion yesterday, are contradicted by the discoveries of to-day. But each newly-introduced witness contributes something to the argument for FINAL CAUSE. And thus it must ever be. It will be found, as science rolls back the vapory cloud of the far-off heavens, that other planets and planetary systems lie hid within their sombre shadows, and that other wonders, more astonishing and mysterious than any yet discovered, are buried

in the bosom of the outward darkness; it will be found also, that each stone turned up by the strong arm of the miner, or the ingenious hand of the geologist, will expose new and perhaps more interesting pages of the fossil history of creation.

VII.

THE FAUNA OF THE CARBONIFEROUS ERA.

Dismissing the flora of this era, which we have seen, fails to support the idea of development, we will now turn to its fossil fauna. Vast forests had been discovered in various places, before the remains of any air-breathing animal were found. Indeed, it was not until 1844 that the true reptilian and bird were discovered in the carboniferous strata. Fishes of the highest order had been found in great abundance, but nothing above them in the scale of animal existence. This was a matter of profound astonishment to many experienced geologists. Is it possible, they inquired, that no land animal inhabited the luxuriant forests which overshadowed the mighty streams of that era? There was, undoubtedly, dry land; this fact is established by the vegetation. What was it, then, that prevented the commencement of terrestrial zoology? And thus the questions

increased. Finally, the friends of development attempted to account for the apparent absence, by supposing the atmosphere of that period to have been unfit for air-breathing animals, from the large quantity of carbonic acid gas which it contained. The carboniferous formation occupied a middle position; and according to the theory of development, immediately preceded the introduction of land animals. In fact, the friends of that theory make it necessary to their introduction.

The existence of the superabundance of carbonic acid gas is inferred from the luxuriant vegetation of that era; and from the limestone which constitutes so large a portion of that formation, and from which it derives its name. It is contended that the vegetable kingdom would not only live, but thrive better in an atmosphere charged with a much larger portion of carbonic acid gas than exists in the present aerial envelope of our globe. But this is very doubtful. "The evidence upon these points is by no means satisfactory," says Robert Hunt, an accomplished chemist of large experience; "and although at one time quite disposed to acquiesce in a conjecture which appears to account so beautifully for the observed geological phenomena of carboniferous periods, we do not regard the necessities for such a condition of the atmosphere as clearly made out."

Experiments are now being made by Dr. Daubeny and Mr. Hunt, at the request of the British Association, to test the ability of plants to receive or repel this gas. Dr. Daubeny is already satisfied that ten per cent, would have been destructive to the plants of the coal formation; and it is doubted by both of these distinguished men, whether vegetation would be at all benefited by an increase of that gas over the present proportion. The luxuriant vegetation of that era must have depended on some other cause than this. Again, it was inferred from the quantity of limestone, that the superabundant gas was taken up and deposited in them; and that it was in this way that the atmosphere was prepared for the introduction of air-breathing animals. We think this inference about as groundless as the preceding, which experiment has proven wholly so.

But, leaving these speculations to those who consider them more important, we proceed to the examination of the reptilian fossil record. In 1844, a true reptile was found in Rhenish Bavaria by H. Von Meyer; and in 1847, three skeletons of similar air-breathing reptiles were found by Professor Von Dechen, in the coal-field of Saarbruch. Of these, the skulls, teeth, &c., with a large part of the skin, have been preserved in the centre of spheroidal concretions of clay iron-stone. About the same time

that the Bavarian skeleton was found, the footprints of reptiles were discovered and described by Dr. King of Pennsylvania. These were found in the Greensburg coal in Westmoreland county. These foot prints were examined by Sir Charles Lyell, in 1846, when he wrote as follows:—"I was at once convinced of their genuineness, and declared my conviction on that point, on which doubts had been entertained both in Europe and the United States. The foot-marks were first observed standing out in relief from the lower surface of slabs of sandstone, resting on their layers of fine unctuous clay."

"No less than twenty-three footsteps were observed by Dr. King in the same quarry before it was abandoned, the greater part of them so arranged on the surface of one stratum as to imply that they were made successively by the same animal. Everywhere there was a double row of tracks, and in each row they occur in pairs, each pair consisting of a hind and fore foot, and each at nearly equal distances from the next pair. We may assume that the reptile which left these prints on the ancient sands of the coal-measures was an air-breathing animal, because its weight would not have been sufficient under water to have made impressions so deep and distinct. The same conclusion is also borne out by the casts of the cracks in the clay, which in some instances

divide the track or footprint; for these cracks show that the clay had been exposed to the air and sun, so as to have dried and shrunk."

"The geological position of the sandstone of Greensburg is perfectly clear, being situated in the midst of the Appalachian coal-field, having the main bed of coal, called the Pittsburg seam, one hundred feet above it, while many of the characteristic carboniferous plants are found both above and below the level of the reptilian footsteps. "Analogous footprints of a large reptile of still older date have since been found (1849,) by Mr. Isaac Lea, in the lowest beds of the coal formation, at Pottsville, near Philadelphia; so that we may now be said to have the foot-marks of two reptilians of the coal period, and the skeletons of four." The location of these footprints has been assigned to the Old Red Sandstone by many geologists; but Mr. H. D. Rogers, who perhaps is the best authority on the subject, thinks the stone in which they are found, belongs to the lowest strata of the carboniferous formation. "After such unexpected discoveries," says Sir Charles Lyell, "we shall do well to be on our guard against the presumption of taking for granted, that our present knowledge of the earliest occurrence of a particular class of fossils in stratified rocks, can be reasoned upon as if it afforded a true indication of the first appearance of a particular class

of beings on the globe. We must not even feel too confident, that some mammalia may not have co-existed with the European Saurians of Saarbruck, or with the American Cheirotherium of Greensburg."

The existence of reptiles during that period, is no longer a question for scientific investigation. But it is still questionable whether a true fossil bird has been found so low down as the carboniferous era. Their remains are rare even in tertiary deposits, and for obvious reasons; they are enabled to avoid casualties by flight; and if they fall or are thrown into the water, their tubular bones and feathers float them on the surface of the stream until they decay or are destroyed by animals. These facts have prevented them from leaving their history in the records of the stone book. But like the reptiles we have just described, many of them have left their foot-marks on the margins of those ancient seas and rivers; and in this way their history has been perpetuated. They were neither scholars nor engravers, yet they have written the evidence of their existence on the solid rocks of the earth. These foot-marks have been found in the strata between the lias and coal; and in a few places immediately above, if not in the coal-measures.

Foot-marks of a great variety of species, including all sizes, from the plover to that of a bird which must

have been considerably larger than the ostrich, have been found by Professor Hitchcock, in the Valley of the Connecticut, in the New Red Sandstone of that district. These foot-marks are found in a strata which Sir Charles Lyell thinks is older than the coal-bed near Richmond, Virginia. This, although it does not prove the existence of birds during the carboniferous era, proves that they had an existence before and at the time a large coal deposit was being made within a short distance of them; and therefore, that it was not necessary that the atmosphere should contain an unusual quantity of carbonic acid gas in order to secure such deposits; for with it, these air-breathing birds must have expired: and it is not possible that the atmosphere of Richmond was at any time different from that of Connecticut. We admit that there is considerable difference between the present inhabitants of those localities; but it is more the effect of education than of atmospheric causes; and it is equally true that they both claim the advantage.

If there were no birds during the carboniferous era, it was not owing to the atmosphere; for there were true air-breathing animals. But we think the evidences quite sufficient to warrant the assertion, that there were birds then as now, and that future discoveries will prove the fact. Before leaving this

interesting formation for the New Red Sandstone, which rises before us, we stop to acknowledge the WISDOM that foretold the necessity, and the GOODNESS that supplied the materials, and deposited the coal beds, for the present and future use of man. It is but one link in that mighty system of provision for the comfort, happiness, and continuation, of the human species; and although a single and simple link, it is one of the greatest importance.

Without this deposit, the shivering nakedness of indolence and poverty would be greatly increased, and the iron fingers of our ingenious machinery would cease their labor. The winds would resume their former control of our commercial intercourse, and the greatest improvements of civilization be partially, if not wholly defeated. We think no one can reflect on the importance of the coal series, without feeling that the want of it was foreseen by the Infinite Eye, that looked through the eternity to come as through the eternity past; and without believing that it was expressly designed to supply the wants, and secure the improvements which were written on the character of man.

VIII.

THE NEW RED SANDSTONE.

In quitting the Carboniferous formation, the friends of the development theory enter the field of the New Red Sandstone; taking no notice of the Permian group; or rather making no distinction between these two groups. The latter, however, is unlike the former, and approaches more nearly the character of the carboniferous series. It is composed almost entirely of limestones of different character. It contains shells in great abundance; fossil plants of an advanced character; like, and in some cases identical with those of the carboniferous flora. Fishes are also found, and many of them are of the most advanced types. But this group, which it will be remembered is scarcely distinguishable from the carboniferous, contains remains more interesting than its fossil fish. In some localities there is a conglomerate of breccia, resting directly on the coal deposits, in which the teeth of Saurians and fractured bones are found. From these it appears, that the reptiles to which they belonged were "allied to the living monitor; and their appearance in a primary or paleozoic formation, observes Mr. Owen, is opposed to

the doctrine of the progressive development of reptiles from fish, or from simpler to more complex forms; for if they existed at the present day, these monitors would take rank at the head of the Lacertian order."

Thus, we find, that each group contributes something of importance in contradicting the idea of development. The New Red Sandstone, which is next in order, is not an exception. According to the theory so frequently referred to, nothing but "the lowest class of the vertebrate sub-kingdom" was found in this group, until an animal was discovered at Runcon, near Manchester, which had the body of a reptile, and the beak and feet of a bird; thus proving, as they supposed, that it had been a link between the two classes. It is necessary only to refer to our previous remarks on the footprints of birds, found by Professor Hitchcock in this group, in the valley of the Connecticut river. These and others of a similar character were found in the lowest strata of that formation, and prove very clearly that the supposed *link* was not necessary, and, therefore, that it had no real existence.

It would be useless to follow the footsteps of these theorists any further. We have seen enough to satisfy any impartial mind, of the perfect absurdity and foolishness of their conclusions, as well as the want

of correctness in the data on which they rest their theory. Reptilian footprints have been found in the New Red, Permian, Carboniferous, and Old Red Sandstone systems; while the skeletons of highly organized fish have been found in the Silurian group below. The highest class of animals, the vertebrate, is represented in the oldest fossiliferous strata. There are no birds and quadrupeds to be found in the ancient beds; but this is because they were chiefly marine deposits; and in such these remains are seldom found.

But, it has been said that the fossils of those ancient formations represent plants and animals, as a general thing, very different from those of the present day. And, as their particular forms and genera cannot be found at this time, it is inferred that they were changed into new forms and families which transmitted their new character to succeeding generations; in other words, that transmutation of species was common, nay, that it was the law of their existence, and their unavoidable and necessary end. But this is not a legitimate conclusion or inference. Species are dying out at the present time, and it may have been the course at that early period. It is thus with the Dodo, a remarkable bird which was found on the small islands of Bourbon, Mauritius, &c., near the coast of South Africa; and the *Nestor productus*,

a species of parrot peculiar to Philip's Island; and the Apteryex, and other birds of New Zealand. These birds are all dying out, yet there is no proof that any of them have perished by what is called a catastrophe. They have wasted gradually away, one by one, as the Bison is now disappearing from the earth.

Circumstances operate to change or entirely destroy different families or species. Animals, like plants, are so constituted that they can bear change to a certain point and no farther; anything beyond will either injure or entirely destroy them. This is true also of man. He is not exempt from the common laws of life. The Indians of this country are rapidly dying out, if such language should be applied to a naturally noble, but unfortunate and badly-treated people. In a few brief years some of the tribes will have disappeared. The last of the Miamies, Pottowatomies, Cherokees, and many other tribes will soon be left to mourn the departed greatness of their fallen people in silent and bitter solitude. Years, nay, centuries, may pass away before this sad event, yet sooner or later it must come. Extinction is written on these tribes as certainly as death is upon the different members. A different course of treatment might possibly avert it for a time, how long cannot be foretold; but the voice of their sufferings, and

the eloquence of their silence, have not yet been able to effect that change, and may not.

These *changes* of species are natural, so far as they are in fact changes; they are not, however, of the character represented. There is no change from one to the other—no transmutation of species. Time produces changes, but these are effected by the extinction of one, and the creation of a different one. And by removing species from one locality to another, which is sometimes demanded by change of climate.

It appears from the review we have taken of this subject, that the geological history of the earth's crust does not sustain the idea of a regular advance from the lowest or simplest, to the highest forms of vegetable and animal organization; but, that it proves the contrary to be true. Among the earliest inhabitants of the world, animals of the first department, and of a high organization, differing in almost every particular from the structure of their more humble associates, are found; and not unfrequently the highest and most perfect remains appear first in the singular record of their history. Professor Owen and other distinguished authorities, say that the general structure of the advanced order of fishes, upon which the transmutationists engraft the simplest forms of reptiles, utterly forbids the idea of the least

possible connection between them. But, if the fossil record clearly established a regular advance of animal and vegetable forms, from the lowest to the highest strata of the earth, it would not prove the theory in question; but only, that each succeeding generation was more perfect than the former. The distinguished professor just referred to, in writing on the subject, expressed the opinion that, the different species in their progressive development would maintain their typical character; and that if any improvement did take place, it would not result in the least change of form or character.

This is the opinion of nearly all of our distinguished Naturalists and Philosophers, and we think the only reasonable view of the subject. A change is not an improvement. While advantageous or disadvantageous circumstances, may improve or injure the organs separately, the nature, form, and character of the plant or the animal, must always remain the same. Professor Agassiz, after being engaged for many years in the observation of fossils, says that he cannot admit the transmutation of species. Again he says, there is a freedom in the development of animate matter, in which the action of an intelligent and omnipresent Creator may be seen.

In the professor's lectures on Embriology, before the Lowell Institute in Boston, he used the most dis-

tinct and satisfactory language on this subject "It has been long and generally asserted," he says, "especially by the physi-philosophers, that the lower animals were first introduced upon our globe, and formed alone the population of the earliest periods in past-time; that Polypi existed before Mollusks; these before the Articulata; and that Vertebrata were the last to make their appearance. But the discoveries in fossil ichthyology which it has been my good fortune to describe in my researches upon fossil fishes, have shown that vertebrated animals—fishes—have existed in the oldest epochs, and that such an order of succession as mentioned before, did not agree with the plan of creation. Indeed, that representations of all the four great divisions of the animal kingdom, Articulata, Mollusca, Radiata, occur simultaneously with fishes, in all the lowest geological formations, was soon ascertained by the investigations of paleontologists, and that the fact of any regular succession was afterwards altogether denied. However, the simultaneous occurrence of the four great types does not indicate the want of regularity in the development of the various classes of the animal kingdon, taken isolately."

Müller, the distinguished German physiologist, says that the species were created, originally, distinct, and that there is not even a remote possibility that

one species has been produced from another. Baron Cuvier bore the same testimony, and he denounced the theory of development as chimerical, and as renounced by philosophy. To this authority we might add that of Murchison, Vernuel, D'Orbigny, Miller, and Lyell, and many others of equal weight; but the facts speak louder than these. Mr. Charles Bell, one of the greatest men England ever produced, whose large experience enabled him to speak in the most positive terms, wrote as follows:—"It is above all surprising with what perverse ingenuity men seek to obscure the conception of a Divine Author, an intelligent, designing, and benevolent Being—rather clinging to the greatest absurdities, or interposing the cold and inanimate influence of the mere elements, in a manner to extinguish all feeling of dependence in our minds, and all emotions of gratitude." In another place, the same distinguished author says: "It must now be apparent that nothing less than the Power which originally created, is equal to the office of effecting those changes on animals, by which they are adapted to their conditions; that their organization is predetermined, and not consequent on the condition of the earth, or the surrounding elements. Everything declares that the species took their origin in a distinct creation, and not in a gradual variation from some original type; and any

other hypothesis than that of a new creation of animals suited to the successive changes in the organic matter of the globe—in the condition of the water, atmosphere, and temperature—brings with it only an accumulation of difficulties." To the weight of such authority, it would be useless to add the testimony of others less distinguished, but not less sincere and positive.

With these historical facts, together with the testimony of the distinguished savans referred to, we will leave this branch of our subject; which, if not as attractive as the astronomical part, is not less interesting and important. The one excites our profoundest astonishment, and leaves us gazing with bewildered look up into the boundless and the infinite, in which the planets hold their orbits, and exercise their varied influences; while the other fixes the mind upon the revelations of the earth's mysterious record, which tells of long ages past, distinguished by different physical and organic forces. But, however different in the character of their phenomena, they unite in proving their common origin and ultimate end.

PART IV.

COMPARATIVE PHYSIOLOGY.

I.

From the vast and mysterious records of nature, upon which the wonders of unnumbered ages have been written, we pass, with increasing reverence, to the widespread field of organic matter. And here, surrounded by the living witnesses of Creative Power and Goodness, we learn facts of deeper interest and more startling significance. Beneath us we see the various fruits of past centuries; the indispensable materials of the present; which internal convulsions and external violence, which life and death, lengthened prosperity, and sudden extinction, have deposited in this mighty storehouse of generations. But over all these successive changes of matter, animate and inanimate, an Infinite Wisdom presided; and out of their ruins a more perfect edifice has been constructed for man. We still have

the humble tenant of an hour, whose progenitors lived and sang before man was; still the varied forms, organs, and remarkable adaptations of each, which enable us to distinguish the exhumed denizens of the earliest periods. Between the multitudinous forms various resemblances exist, but they result from the necessity which similar constructions and instincts create. There is a universal harmony in the discordant members. As music is composed of different sounds, so God, in his wisdom has created a perfect whole out of innumerable and apparently contradictory parts. The earth is diversified with frowning mountains and smiling plains; with barren and with fertile spots; with arid deserts and ocean depths; it is clothed with the lichen and the oak, and tenanted by different species, classes, and departments of the animal kingdom, each of which performs a distinct office. The mountains feed the springs and rivers which supply the intervening valleys. The inequalities of the surface serve to relieve it from a superabundance of water, and the depths of the ocean receive it. And although the desert appears useless to man, it may not be less important in the economy of nature than the ocean by which it is surrounded.

Certain philosophers consider the various organisms simply different forms of the same life; not

separate and distinct creations, but the legitimate offspring of the same common parents; that through an instinctive longing for improvement, the inferior gradually but steadily advanced to the superior. If this is true, the changes must have been uniform, and the superior and inferior composed of the same constituent elements. It is our purpose, however, to show that this is not the case. To do this, we will attempt to draw the line of distinction between the various forms and divisions of the vegetable world, and successively point out the differences which exist between the vegetable and animal kingdoms.

It becomes necessary, in the development hypothesis, to establish the existence of some connecting link between the grand divisions of organic matter. If no such connection exists, the possibility of a change of character or transmutation cannot be sustained. In each division of the vegetable kingdom, the embryos are marked by peculiarities by which they are easily distinguished. "The monocotyledonous embryo is of an ovoid form, or like a cylinder rounded at its extremities. The dicotyledonous embryos are sometimes similar in form, but are always distinguished from the monocotyledons by the division of the cotyledonous extremity into two lobes. The gemmule in the monocotyledonous embryo occupies a cavity in the inside, and differs in the elonga-

tion of the axis." The embryos are dissimilar, and this difference finally decides the character of the plant. But not only in form are they different; the elementary particles are not the same in the very beginning of its growth. This variety of form and of elements naturally secures different powers; and as a result it is found that the functions performed by the one are beyond the powers of the other. "Vegetable substances, apparently identical, not only present themselves under entirely different forms, but they also produce (in the poppy, for instance) certain bodies, which are entirely different from those produced either in the aconite or in the oak tree; nay, in different organs of the same plant they give rise to entirely different products, and perform entirely different functions." The constituent materials are different, and these produce a difference in form, which finally results in the production of a different wood and fruit. The whole depends on the combination of the constituent elements. These are differently combined in the various families, and therefore they take dissimilar forms, and perform entirely different functions. If these facts are granted, it must be admitted that the first visible form of the plant results from, and is in accordance with, the primary arrangement and combination of its elementary parts.

The incalculable variety of the organic kingdom depends, not so much on the variety of the inorganic materials, for these are few and simple, as it does on the admixture of them. After this combination, which is the first step to, and sign of, organization, takes place, the energies of that combination develope the plant; but this development is involuntary, and necessarily confined to certain and unchangeable limits. The form and functions of the plant, therefore, are determined by the Power which secured the combination of its constituent elements; and not by any peculiarities or dynamic difference to be found in the inorganic substances. As the plant has no existence until this combination of elements takes place, its whole character depends on the combining Agency; and this must be distinct from and prior to the plant itself, giving it its fruit in the season, and withering its leaves and branches at a word, whenever exhibitions of Infinite Power are necessary to instruct or admonish those whom kindness cannot reach.

While the great variety of plants depends on the primary combination of the inorganic substances, it is effected through the action of differently constructed organs. For this purpose the organs are variously constructed and arranged. Plants containing alkali possess organs fitted to produce it; and those abound-

ing in acids have organs peculiarly adapted to their production. Thus, various substances are elaborated out of the same soil, and plants as dissimilar as any found in the whole vegetable kingdom are made to flourish almost in the embrace of each other. This provision and adaptation is highly important in the economy of life. The *antiaris toxicaria*, one of the most poisonous plants in the whole range of vegetable matter, may be found by the side of the most innocent and useful. The poisonous vine springs up out of the same soil that sustains the tree whose trunk it entwines, and around whose delicious fruit it gathers in beautiful but fearful festoons. We have seen some of the rich fruits of the tropics thus protected from the touch of man, and compelled, as if by some curse, to ripen and decay amid the flowers which surrounded them.

From this very limited notice of the elementary materials, and the force of different combinations, we pass on to the growth of the embryo, which is peculiar in each of the grand divisions. The monocotyledonous seeds are generally provided with a perisperm, and in such cases the cotyledon is not disengaged from the seed. It forms either an elongation on the outside by which it is attached to the axis, or remains sessile on the axis. When there is no perisperm the cotyledon is separated from its

integument, and raised vertically with the gemmule. The germination of the dicotyledonous embryo is entirely different; in it the gemmule comes out of the interval of the cotyledons at their base, and not out of the interior of a sheath. The gemmule is freely lengthened in its direction, while the exorhizal radicle pursues an independent course. Acotyledonous plants are destitute of the organs we have just described, and their germination is necessarily different. Their *spores* are disconnected from the cavity which encloses them, and do not open to give passage to any interior formation, but germinate by an elongation of themselves. They are the simplest form of the reproductive organ, and have little or no resemblance to the complicated structure of the ovules of the phanerogamous plants.

These are the leading distinctions in the growth of the divisions. But, according to Professor Schleiden, the differences exist in the earliest stages of the cellular tissues. The gummy solution is taken up and thickened into a jelly, which is changed into *cytoblasts* or germs. These take forms peculiar to each class; in the dicotyledonous plants they are rounded lenticular bodies, while they are more oval and much larger in the monocotyledons.

This distinction in the form of the Cytoblasts in the various classes, corresponds with the difference

in the forms of the globules of the blood of herbivorous and carnivorous animals; and if the same experiment could be made on the vital forces, we think they would be found as essentially different as the globules of the blood. The blood is a transparent fluid, full of small globules, which differ in number and form, according to the character of the animal. In man they are small and nearly circular. In fishes and birds they are larger and of an oblong spheroidal form. In reptiles, they are still larger and have a different form; and in each of the grand orders of carnivora and herbivora, they are peculiarly marked; so much so that the blood of one order is easily distinguished from the other under the microscope. The distinction in the size and form of these globules is wholly arbitrary; yet the vital energy depends on their number and character. If an animal is bled to syncope, and the blood is permitted to flow on, death will speedily ensue; but if blood of a similar character, containing globules of the same size and form, be injected into the veins before the animal be entirely dead, it will recover. Experiments of this kind were frequently made during the seventeenth century, under the name of Transfusion. In this way it was ascertained, that the vital principle of the globules depended on their size and form; and that the blood of the herbivorous animal would

not answer for injection into the carnivora. If blood with circular globules be transfused into the veins of an animal whose blood contains elliptical globules, or *vice versâ*, the animal will not recover. Dissimilar globules have the power to rouse the animal for a time only, but do not restore it.

Thus, in the globules of the blood, in the rudimentary particles of the body, we find a distinction on which life depends. If life is everywhere the same, and all animals are connected with and spring from each other, how came this difference in the blood? There appears to be no physical cause for it, and yet it is connected with the highest functions of the body. Certainly, if the blood had been transmitted from one animal to another, in a natural descent, it would have maintained its primary character. The globules of the lowest and the highest would be of the same form, and possess the same vital energy; but such is not the case. The globules differ not only in all the departments of the animal kingdom, but also in each class and order; and in the fishes, reptiles, and birds, the difference is observable in almost every family. In the great divisions, the differences are marked, but they become less distinct in the various orders and families. Admitting all that the advocates for transmutation or development desire; that the natural longings of the animal, and the circum-

stances surrounding it, might change the length, location, and even the character of the limbs and organs, yet these new circumstances could not change the globules of the blood; nor is there any perceivable reason for such change. These peculiarities in the blood exist under similar circumstances, and depend, not on external relations, but on internal necessity.

We find the same diversity of form in vegetable cells or utricles, as in the globules of the blood. Some of these cells are round; others are oval; and others are lengthened and sharpened at the ends; while others assume tube-like forms. These forms are modified by growth and pressure, by which means they are forced into spheres, ellipsoids, polyhedrons, cubes or dies, prisms, dodecahedrons, &c. Now, what law regulates these forms? These first steps, or elementary peculiarities, are not governed by the plant; for they are the beginning of the plant, and as such indicate its character. We know that the various families are composed of utricles, fibres, or vessels, peculiar to themselves, and that the flowers of each family have their own fixed number of whorls, and similar leaves, and that the fruit of each partake of similar properties; beyond this, science has not been able to penetrate. It has been said that the organs are the same, which, in a series of trans

formations, have assumed the different modifications we have seen. "Observation," says M. Jussieu, "which proves the truth of theories, determines the contrary. On watching the development of a vessel, we do not find any one which in its different phases would have represented all the other kinds of vessels; and the same thing may be said of cells. Remark, moreover, first, that in each part of a plant such and such modifications of cells, of fibres, of vessels, are found. We have, for instance, in certain places, unrollable trachæ, though in others we never meet with them. Second, that in spite of the similarity of the chemical composition of the walls, that of their contents is quite different, and like the shape, constant in appearance, and agreeing with the place which the cavity occupies in the vegetable. Thus, therefore, if all the elementary organs of vegetables commence their growth as utricles, among which we cannot discover any appreciable difference, except in their form, it is no less true that each utricle is destined from the beginning to assume, in its ulterior development, such a form, and no other; to contain or to elaborate such a substance, and no other, it is not, therefore, always the same organ."

We have seen that the vegetable embryo or germ, is different in the various classes, and that each class has its own peculiar mode of germination. Animal

embryos are also distinct in character; for, however close the resemblance, there is a distinction which, if beyond our optical power at first, soon manifests itself in their growth. There must be something in the embryo which gives direction to the individual growth; or there is an INFINITE POWER presiding over the development and growth of each one. This position proves the immediate interposition, as well as the omnipresence, of the SUPREME CAUSE; and the former establishes the distinct and unchangeable character of each class. One of these positions must be correct; and as both of them contradict the idea of transmutation or development, it is not important which one we force our antagonists to accept. "We know that one sort of an egg will only give rise to one sort of an animal," says the learned Agassiz: "therefore, we must admit, that as an egg of one kind gives rise only to one sort of an animal, there must be an immaterial principle presiding over these changes, which is invariable in its nature, and is properly the cause of the whole process." And as in the case of vegetable embryos, those of the animal kingdom are developed in different ways. In some of them the yolk of the egg is divided and subdivided into innumerable little masses; in others the division is only partial; while in others the germ is elongated, and not divided at all. This division is

effected differently in different animals. Thus in fishes, the yolk is first depressed, then divided into halves, and then again at right angles; in other animals, the yolk is divided into four equal parts, and these subdivided into small yolklets. Indeed, every species, as with vegetables, has its own peculiar mode of division, elongation, and growth. The germs of some animals are surrounded by two or more envelopes; in others there is only one, as in fishes. In reptiles and mammalia there are two. These envelopes are differently formed, and arise from different portions of the yolk. Thus the radiata begin their growth by the formation of a distinct layer round the yolk, in the form of a spherical crust; while the alimentary cavity is formed in the lower part of the yolk. In the articulata the germ is formed in the lower part of the yolk; thus, occupying a position directly reverse to that of the radiata. The first stages of their growth are distinguished in this way. But, if all these germs were developed in the same manner; if the same division took place with a similar growth, the fact of an essential difference in its germinative principles could still be maintained. Vegetables stand by the side of each other, and draw their nourishment from the same soil, yet are different in their form and chemical properties: and animals living on the same kind of food have

different organs, or similar organs with diversified powers and properties. The primordial elements are separated by the action of the digestive organs; and new combinations are formed by the assimilative powers of the animal system. In this formation some law must be observed, which is either stamped on the germ itself, or is obedient to the will of the POWER from which it derived its existence and vital force.

But, leaving the cell and germ, let us turn to the bud. In addition to the difference which, in obedience to the primary law, determines the character of the plant, we here find certain adaptations to location, climate, and circumstances, alike interesting and beautiful. In warm climates, where there is no danger to be apprehended from the temperature of the atmosphere, the first leaves are as complete as the subsequent ones. But in northern latitudes, and on the mountains of the south, the first and outer leaves serve as envelopes for the rest. They are adapted to the nature of the plant and the temperature of the climate. Some of them are hard and dry, like the envelope of a pear; others are impregnated with insoluble matter, and are bad conductors of heat; while others are covered with a thick down. In these arrangements in the vegetable creation we find the first marked evidence of PROVIDENTIAL care.

The growth of the dicotyledonous bud differs ma-

terially from that of the monocotyledonous. In the former, the bud develops itself, and then stops and prepares a bud for the following year. The stem, therefore, is composed of branches placed end to end, and exhibits the number of ligneous layers from the base to the top. In the latter the stem is simple, and there are no lateral ramifications. The bundles or fascicles, composed of small vessels, are scattered in the monocotyledonous stem, without any apparent order; while those of the dicotyledonous stem are arranged regularly in a circle, and approaching, touch each other, thus forming a ligneous ring. The fascicles of the dicotyledons are uniform in their structure; but those of the monocotyledons are irregular both in thickness and composition. The dicotyledonous fascicle is divided, after a certain period; but such a division never takes place in the monocotyledons. These peculiarities in their growth, induced Desfontaines to divide the vegetable kingdom into two great classes:

"First. The Monocotyledonous, or those which have no distinct concentric layers; whose solidity *decreases* from the *circumference* towards the *centre*, and in which the pith is interposed between the fibrous fascicles, without medullary elongations, into diverging rays.

"Second. The Dicotyledonous, or those which

have distinct concentric layers; whose solidity *decreases* from the *centre* to the *circumference*, and in which the pith is inclosed in a longitudinal canal, with medullary elongations, into diverging rays."

The trunk of the monocotyledon is formed by the addition of fresh fascicles from the centre. As these push themselves up, the outside ones are compressed, and thus become harder than the internal ones. This manner of growth is directly inverse to that of the dicotyledonous plant. In this the new layers are outermost, and therefore we find the centre of the plant the most compact. These peculiarities in the distribution, arrangement, and growth of the fascicles, and the difference in their form and structure, enable the initiated to determine the class to which the stems belong, without seeing anything but the stem; and it is by these that the plants of the coal measures are classified, and the character of their vegetation is known.

The bark of the vegetable kingdom is also marked by certain peculiarities. The bark of the dicotyledonous plant is composed of several parts; the epidermis, cortical layer, cellular layer, and cortical fibres or liber. The suberous and cellular layers found in the dicotyledonous division, are never distinctly developed in the monocotyledonous plants, nor is the liber to be found in the latter. But not

these alone; there are shades of difference in all the parts, too fine to be easily detected: many are known to exist by the influence only which they exert on the plant.

In passing to the leaves we are met with differences equally characteristic. The leaf is either palmate or pinnate, according as the petiolary fascicle is divided into divergent ones, or continued in the medium line. The dicotyledonous plants have articulated leaves, with dentate and crenate outlines, and are divided into lobes by angles. They either radiate like the spokes of a wheel, or follow the plane of the petiole. The monocotyledon is more uniform and simple, and is not marked by that net-work of nerves which we find in the dicotyledons. The three great classes have nearly the same combination in the spiral arrangement of their leaves; the angles of divergence constitute the principal difference. The monocotyledons have generally three leaves to the whorl; while that arrangement is scarcely ever found in the dicotyledons.

Leaves which live under water differ very much in their construction from aerial ones; but this depends on the element in which they live. They have no epidermis, and consequently no stomata; while lengthened cells take the place of the fibro-vascular skeleton, which we find in aerial leaves. The paren-

chyma alone composes the leaf. Its cells are very closely united, but frequently present enlarged lacunæ, which are regular in form and arrangement, and are completely enclosed by the surrounding cells. These lacunæ are adapted and appear destined to diminish the specific gravity of the leaf, thus performing functions analogous to those performed by the bladders of fishes. The character and arrangement of the cells of the epidermis regulate the number, position, and form of the exhaling or cortical pores; which are known by the name of stomata, and are different in each of the great divisions of the vegetable kingdom.

The flowers of monocotyledons have five whorls, each containing three parts; while the dicotyledons have four whorls, with five parts in each. This is the leading distinction between the two classes: there are others, however, more or less important, by which the minor divisions are distinguished from each other. But the variations never become parallel to each other; the distinctions, however slight, are maintained through all the divisions and subdivisions of the kingdom. The multiplicity of forms and colors, each with a peculiar fragrance, and the great variety of pistils, petals, stamens, and stigma, are sufficiently marked to impress the most careless observer. They are so inseparably connected with every idea of

delicacy and beauty; such fit emblems of elegance and purity, that he is unfortunate indeed who does not understand their language, and the lessons they are perpetually repeating.

The Roots of the different classes have less to gratify the senses, but quite as much to convince the judgment in an inquiry like this. In the acotyledons there is no distinction of parts in the embryo; the roots are simply tubular elongations of the cells touching the soil. But in the monocotyledons and dicotyledons, the radicles are distinct in the embryo, yet they are developed differently in each. In the first, the embryo is pierced to allow the radicle to pass, and is covered by a superficial layer, which forms a sheath for the root. In the latter, the radicular extremity of the axis is lengthened into what is called the tap-root, which throws off other roots sufficient to support the tree. The monocotyledonous roots are generally compound, but do not throw off so many branches as the dicotyledonous roots. The arrangement and development of the vessels differ materially from that observed in the stems. As the radicle is not found in the acotyledons, there is no analogy between their growth and that of the other classes. These cells are lengthened analogous to the epidermis, and accomplish their destiny by throwing off adventitious roots.

The respiratory organ differs in the different classes of vegetables, as in animals of different grades. The air enters through the stomata on the leaf, and penetrates the parenchyma and other layers before it reaches the cavities of the trachæ; but the trachæ is not the only respiratory membrane. Some plants (the ferns for instance) have no true trachæ, yet their respiration is perfect. These organs, however, are not able to effect the necessary chemical changes without light, the great vivifying agent. The plant in respiring decomposes the carbonic acid gas, and retains the carbon and a small portion of oxygen; but the solar action is indispensably necessary in the process. When plants are kept in the dark they lose their color and solidity, thus proving a loss of carbon, on which their solidity depends. During respiration vegetables throw off oxygen, and take up carbon; but at night when respiration ceases, they throw off carbonic acid gas. The decomposition and consolidation of the elementary substances are effected by the action of the sun and water, while the color of the plant, and the growth of the woody parts, depend more directly on the elements of the solar rays, and the composition of the atmosphere.

As it is our object to show the fallacy of the idea of transmutation, and the development hypothesis, not only from the distinctions in the vegetable and

animal kingdoms, but also from their adaptations to each other, and to the world of matter around them, it is proper to notice the harmony which exists between the vegetable kingdom and the laws of heat and light, and the revolutions of the earth. It has been ascertained that a ray of solar light contains several distinct principles; one portion represents color, another affects the temperature, while a third contains the chemical principle, which is invisible, and has no influence on the thermometer. Vegetation is regulated by the seasons; but what agency does light, and especially the harmonious action of these distinct principles, perform? This question was before the British Association last year, and submitted to Mr. Hunt for investigation. From his report, it appears that light transmitted through yellow glass has little or no influence on the germination of seeds, from the fact that the chemical portion of the ray will not pass through that color. Every vegetable requires a certain portion of all these principles, and will not survive without them. And it is upon the changes in the proportion of them, that germination, growth, and fructification, depend. These changes are in harmony with the seasons, and may result from them. "It is now an ascertained fact," says Mr. Hunt, "that the solar beam during spring contains a large amount of the actinic principle, so neces-

sary at that season for the germination of seeds and the development of buds. In summer there is a large proportion of the light-giving principle, necessary to the formation of the woody parts of the plant. As autumn approaches, the calorific or heat-giving principles of the solar rays increase. This is necessary to harden the woody parts, and prepare them for the approaching winter. It is thus that the proportions of the different principles are changed with the seasons, and thus that vegetation is germinated, grown, and hardened by them." We know not how these facts may act on the minds of others, but in the axis of the earth, so arbitrary yet so essential; in the distinct principles of solar light, so mysterious, yet so powerful and important in their action on vegetable life; and in the adaptation in the proportion of these principles to the seasons and necessities of the kingdom, we recognize the strongest evidence of the existence of an INFINITE WISDOM and an ever-active GOODNESS.

The growth of the wood is also different. We have seen that one class has its growth externally, and another internally; there are differences also in the form, growth, and arrangement of the trachæ, cells, lactiferous vessels, and fascicles. The elements of the fascicles of the dicotyledonous plant are divided after the first year; one part remains as the

ligneous, while the other becomes the cortical system. This division never takes place in the monocotyledons. In the acotyledons the fascicles have another arrangement, quite distinct from either of the former. They have no unrollable trachæ; indeed, they differ in every particular. Their stems grow at their summits, by the lengthening of the fascicles already formed, which is wholly unlike the manner of growth in their kindred classes.

II.

VEGETABLE VARIETY AND ADAPTATION.

It is truly wonderful to contemplate the multiplicity of forms found in the vegetable kingdom; but our astonishment is increased when we think of the different powers which these various forms possess. The perfect adaptation of their organs to the offices they perform, and the infinite chemical combinations elaborated by them, force us to recognize them as separate and distinct creations. In this review of the distinctions in the forms and functions of the principal divisions of the vegetable kingdom, we have not been able to find *the* point in the different plants, or periods in their growth, in which the distinct features are blended in each other; or when they in the least

appear to blend. Indeed, no such point can be found. The characteristic features are stamped indelibly on the elementary parts, and continued through all the various stages of their growth and decay. They never represent each other; never run into each other, but are always the same; performing the same functions, elaborating the same substances, and working out, through the mysterious process of their growth, the same peculiarities and forms.

The question now presents itself; is it probable, or even possible, that these differently constituted plants sprung from the same parent stock? Their constituent elements are differently combined; their forms are dissimilar, and their organs or tissues are not only unlike in themselves, but elaborate different substances out of the same soil, thus proving that they have different powers, and that they are in fact and in every particular distinct from, and independent of, each other. If any such transmutation took place in the early ages of the world, would we not know something of the fact, through the pages of botanic history. By various means the history of many plants has been transmitted regularly down from century to century, yet no change has been observed in their character. The seeds taken from the monuments of Egypt produced plants precisely like those of the present day; yet centuries must

have passed away with their innumerable events and changes, since those seeds were first locked up within their mighty vaults. During this period of time, no change has taken place in the vegetable kingdom. A few plants have suffered some slight alteration by cultivation and change of locality; but none whatever in their chemical properties or elementary principles; these remain essentially the same.

If in addition to the distinctions which we have seen, there appears to be an important end obtained by them, the conclusion to which they point will be the more irresistible. He who contemplates the variety and beauty of the vegetable creation, and enjoys the fragrance of our gardens and prairies, without feeling grateful to the AUTHOR of their existence, who ordered the variety of their colors to please, and their sweetness to gratify, is sadly deficient in all that refines and ennobles humanity, and needs some correcting influence to quicken his sensibilities and prompt his gratitude. Yet these are subordinate offices only, when compared with the more important parts they perform in the economy of nature. Nor do they merit much consideration when viewed as evidences of original design. It is the adaptation of the vegetable families to the performance of their multiplied offices, their distribution over the continents, their chemical and medicinal

properties, and their general usefulness to man, which most clearly prove them to be the offspring of an intelligent and kind CREATOR.

It has been said that it was quite as important to provide for the wants of man as to create him. But the great question involved in the theory of development is, not whether it was necessary to create him, but how he *was* created! By what direct and intelligent power, if by any? Did the same wisdom provide for his wants that gave him life? or did these supplies result fortuitously from the operation of the forces which elaborated the human soul? In the distribution of vegetables we find much that is interesting and instructing. In the vegetable creation, as in everything else, a general compensation takes place between the different portions of the globe we inhabit. The absence of one is compensated by another; so that the various climates are supplied with different vegetables, answering the same important ends. The most useful, however, have a wider range, and seem to be adapted to a greater variety of climate. The *cereals*, which are pre-eminently the most useful, are successfully cultivated as far north as the seventieth degree of latitude. But this depends on the modifications of the climate, for they are not usually found so far north. Their boundary varies between fifty-one and seventy degrees north latitude. Wheat is

produced in Scotland, England, France, Germany, Hungary, Central Asia, North America, Brazil, Buenos Ayres, Chili, at the Cape of Good Hope, New South Wales, and New Holland. In Spain, Portugal, Italy, Greece, Asia Minor, Syria, Persia, and South America, maize and rice take the place of wheat. Rice supplies its place in China and Japan, but it is not confined to those countries, it is successfully cultivated in both divisions of the western world. Rye and barley are scattered from the seventieth degree north latitude, as far south as Van Dieman's Island. Thus it appears that these, the most useful of all plants, are adapted to almost every climate on earth.

But in the low countries, between the tropics, other vegetable products are provided to supply the wants of man. The banana, date, cocoa-nut, yam, and bread-fruit trees, are scattered over the whole intertropical zone. They commence where the *cereals* stop, and appear to be better adapted to the inhabitants of those warm climates than those which their climate denies them. These grains and fruits are adapted to a great variety of climate and soil, while those less essential are frequently confined to very small territories. The loss of one is compensated by the spontaneous growth of another, answering the same purpose, and almost always better adapted to the

inhabitants of the country in which it is found. This power of accommodation, and ability to mature under so great a variety of circumstances, are not given to other divisions and families of the vegetable kingdom. Many of the largest, and apparently the hardiest, plants and trees are confined to very limited zones, and soon wither and die if removed beyond them. This is perfectly natural, for each locality and climate requires a distinct, we might say peculiar, organization of the nervous and respiratory systems. The mountain-plant cannot thrive in the valley, nor the valley tenant on the mountain-top. If these changes are made the plant will soon wither and die.

Next in importance, are the vegetables and plants used for chemical and medicinal purposes. This field is so large that a few only can be mentioned. In this we will discover the results of the different organs heretofore referred to. In one family, we find the *Euphorbia Ipecacuanha*, *Castor-oil plant*, *Tiglium*, *Janipha*, *Manchineel*, etc. These are found together, yet how different in character. From the first, second, and third, some of our best and mildest, as well as our most active purgatives are derived. The janipha supplies food for a large part of the population of South America; while the poisonous shade of the manchineel verifies the extravagant stories about the deadly *upas*. In another family we find the hop,

hemp, mulberry, fig, Indian-rubber, bread-fruit tree, and *antiaris toxicaria*. Here is a most remarkable combination of dissimilar properties in the same family. The bread-fruit tree, so important to the inhabitants of the South Sea Islands, the hemp which is invaluable in commerce, the hop equally important in brewing and cooking, and the Indian-rubber, which is becoming more and more useful to man. The fig supplies us with a most valuable fruit, while the antiaris toxicaria yields strychnine, an alkaloid, very useful in chemistry and medicine.

In addition to these, we have the rhubarb, *mirabilis*, *jalapa*, *cistic creticus*, mustard, poppy, kalumba, cassia senna, *capaifera*, etc., all esteemed for their medicinal properties. It has been said, and we think with much truth, that every country and climate produces, in the form of vegetable and mineral compounds, all the remedies that the diseases of each locality require. Nature, like a vast chemical laboratory, is constantly preparing and storing up all that is needed as astringents, febrifuges, oils, acids, cathartics, tonics, emetics, etc.; all the apparent deficiencies result from our ignorance of the medicinal properties of the indigenous plants. It is thus that man is armed with remedies and antidotes against the many disorders and derangements of the human system. But the goodness of the CREATOR stops not

here. Every where in nature, from the fragrant flower of the desert, to the indescribable display of power above our heads, beauty is inwrought with the useful. The flowers might have been as fragrant without the varieties of form and color, which make up their beauty; but without these the charm of the flower-bespangled lawn would be gone, and the soul compelled to remain untouched by such scenes of beauty. The countless stellar systems might have been arranged by the ALMIGHTY hand to perform their various offices in the universe, without shining upon this nether sphere; but such an arrangement would have robbed the heavens of those softly beaming eyes of the outward space, and left the world without their cheering light. No starry sentinels would have been left to tell the sad and lonely, of other states of existence, and of other beings who look down from those distant orbs with earnest, anxious gaze, upon our toilings here; or to bring back with the long train of dreamy thoughts, life's half forgotten joys, and fill the throbbing heart with hopes of others yet to come.

> ——The distant planets all
> Are fill'd with radiant creatures; and the heart
> Becomes interpreter, and language makes
> Out of its sad sympathies, with which
> It seeks to write their histories; but oftenest
> Writes its own, yet knows it not.

Abundant provision is also made to gratify the different tastes of mankind. The *Rese da luteola*, *Logwood*, *Indigofera*, *Anchusa tinctoria*, supply the materials for coloring and enriching the plain fabric which the cotton plant and mulberry leaf enable animal ingenuity to construct. We refer to the peculiar properties of the mulberry, not forgetting the fact that man, with all his boasted superiority, is a dependant on the worm, too frequently crushed beneath his feet, for much of all that is elegant in his apparel. The silk-worm cannot accomplish the object of its creation without the mulberry leaf—the substance on which it feeds—and God, as if to ensure the continuation of this useful species, has so ordained it, that no other insect will partake of the same food, thus ensuring a certain supply for the little spinster. This appears to be a small matter, yet it as clearly exhibits design and goodness in the creating Power, as the laws which hold the bodies of our astral and stellar systems together.

Other vegetables furnish genius the means of perpetuating the features of the departed, and of transferring to canvas all that is sublime and beautiful in natural scenery. To these beautiful provisions for supplying our wants, and securing our happiness, a great variety of fruits has been added, which if not necessary, appears almost indispensable. Numerous

as are the tastes and desires of the human family, they are all supplied from nature's inexhaustible storehouse. All around us minister in some way or other to our good. Every noble sentiment of the heart finds something without to purify and increase it. Thus all our longings for the undefined and invisible are insensibly fixed on the future, and the higher faculties of the soul thus gradually fitted for the enjoyment of the unknown treasures of the Infinite and Eternal.

We have seen the relation the vegetable kingdom sustains to man, in supplying his wants and gratifying his desires; we now turn to view the adaptation of the various families to their locality: and the general and very important offices which they perform in the economy of nature. And first their adaptation. Plants indigenous to mountains and dry wastes have gutters in their leaf-streams, by which the moisture they collect on their leaves is conveyed to their roots. They have a power, also, by which they attract water from the vapor in the air more speedily than other plants. The *puricaria* possesses this power in a remarkable degree. We are assured by travellers that there is a tree in the mountains of Ferro, which furnishes the inhabitants with large quantities of water by distilling it from the clouds which it attracts, and depositing it in reservoirs

around the tree; from which it is drawn by the inhabitants. Many of the plants of low grounds have their first leaves in the form of furrows or little spoons; such as the violet, and many of the grasses and grains. In the spring, these tufts of young leaves raise themselves up towards heaven like paws, to catch the falling drops. Most of these leaves lose their gutter form as they grow older. It is permanent in mountain plants only, and there it is always necessary. In these it remains to conduct the rain-water into the tree. The branch, by its obliquity, conveys it to the trunk; from thence it descends to the roots. The bark is adapted also to this important office; as it always is cleft lengthwise, and never across.

The corolla of flowers is adapted to the heat of the sun; and their duration depends on the quantity of heat which they collect. Some of them are protected by their form from the rays of the sun; while others sustain the full effulgence of his rays without injury. Some are provided with dusky reflectors; others have the power of closing as occasion may require; and others are provided with parasols, by which they protect themselves, like the crown imperial, whose flowers are shaded by a plume of green leaves. Some have curves, by which they collect the heat at the centre; while in others the curves are so arranged that they are able to dissipate the heat. Thus, not

withstanding the large size and whiteness of the cup of the lily, the more it expands the more it disperses the heat. In midsummer, at noon-day, when all other flowers seem exhausted, it lifts its head above its drooping associates, and triumphantly disperses the rays of the hottest sun. Other flowers have provisions to protect them from the cold; while another family is adapted to bloom on the surface of the water; such as the *ugurphoca*, which floats on the margin of lakes, and accommodates itself to the motion of the waves, without having its centre wet by them. The *valesneria* are remarkable examples of this class. They grow abundantly on the Rhine, and would be exposed to frequent inundations by the sudden overflows of that river, had they not been provided with stems formed like cork-screws, which easily stretch out to the length of three or four feet, and when the water subsides, settle back again like an elastic spring: in this way they keep their blossoms always on the surface of the water.

But the provisions for protection are not confined to external objects; many buds are protected from their own stems. While very small and tender, they are wrapped in a tough integument, called *calix;* and the more rough and branching the plant, the thicker the calix. This calix is sometimes in the form of a cap, armed with bristles, as may be seen in the

rose. These protections are never found on flowers that grow on stems without branches. The holly is provided with means to defend itself from external violence. The edges of the leaves are armed with long sharp spines, up as high as cattle can reach; but as they are safe above that point, and the protecting spines are no longer necessary, they are found to be perfectly smooth. Southey says:

"Below, a circling fence, its leaves are seen,
Wrinkled and keen;
No grazing cattle through their prickly round
Can reach to wound;
But as they grow where nothing is to fear,
Smooth and unarmed the pointless leaves appear."

"Oftentimes we see some herb which has flowered in the midst of a thorny shrub," says Mr. Lyell, "when all the other individuals of the same species, in the open fields around, are eaten down, and cannot bring their seed to maturity. In this case, the shrub has lent his armor of spines and prickles to protect the defenceless herb against the mouths of the cattle; and thus a few individuals which occupied, perhaps, the most unfavorable station in regard to exposure, soil, and other circumstances, may, nevertheless, by the aid of an ally, become the principal source whereby the winds are supplied with seeds which perpetuate the species throughout the surrounding

tract. Thus, in the New Forest in Hampshire, the young oaks which are not consumed by the deer, or uprooted by the swine, are indebted to the holly for their escape."

Thus, we see how plants are protected from themselves, the different parts from each other; and how they are armed with defensive spines to protect their parts from animals, and to shield each other. We might show, also, how they are protected from the intrusion of each other by insects; and how these insects become the means of preserving the balance in the vegetable kingdom; how they stay the progress, or perhaps entirely destroy one to encourage and protect another; there is scarcely a beast that will touch the nettle; yet many insects are fed by it. They live on different parts of it, and greatly check its growth. Were it not for this fact, it would entirely root out and destroy many valuable plants. By such means the mighty balance in the variable and conflicting elements is maintained, and the harmony of the creation secured. A most striking evidence of a universal arrangement and adaptation; and of that dependence which the ALMIGHTY CREATOR has thought it best to write upon all his subjects.

III.

DIFFERENCES IN THE TWO KINGDOMS.

Having thus briefly noticed the distinctions in the vegetable kingdom, we will now invite the reader's attention to those which exist between the two kingdoms. And first as to the phenomena of life itself, which will be found to be different in every particular. Vegetables have the power merely of supporting themselves, and of reproducing their kind; while animals have the faculty of determinate motion, and of receiving and perceiving external impressions. Animals are endowed with a greater number of faculties, and are therefore necessarily supplied with more complicated organs But the differences are not confined to the organs; the structure of the tissue is very dissimilar. The tissues of vegetables are composed of cells or utricles, furnished with walls, hollow in the centre. In animals, the tissues are composed of filaments or laminæ, which intercross each other, forming membranes more or less spongy; but these are not always divided into cells as in vegetables. These cells are sometimes found in animals; but it is somewhat doubtful whether they are natural and permanent. We prefer to adhere to the opinion

generally entertained, before the investigations of Professor Schwann. His conclusions have not received the unqualified approbation of our most distinguished physiologists. Professor Agassiz speaks of the results of Professor Schwann's investigations approvingly, but thinks they will be somewhat modified. Previous, and we may add with equal truth, subsequent investigations are against the professor. He has not been able to explain the peculiar stages of development in animal tissues by the cell theory. The chemical composition of these cells is peculiar in each of these kingdoms, and also in each of the grand divisions of the kingdoms. Cellulose, composed of nearly equal parts of carbon, hydrogen, and oxygen, forms the principal part of the cellular mass in plants; while gelatine, composed of unequal parts of carbon, hydrogen, nitrogen, and oxygen, is the primary material in animals. To this rule Professor Mulder says no exception has ever been discovered. The skeletons of vegetable tissues are composed of carbon, hydrogen, and oxygen only; while azote or nitrogen is united with them in the tissues of animals. Azotized matter is sometimes found in vegetables, but it does not appear to be necessary or natural to them. These differences are easily detected when the membranes are decomposed either by age, or by some artificial process, which does not destroy or recom-

bine the constituent elements in the act of decomposition.

These kingdoms present the greatest distinction in their growth. Vegetables absorb inorganic particles by the extremity of their roots; while animals feed upon organic particles, and absorb their nutriment by the ramifications of the nervous and lymphatic vessels in the intestinal tube. The food of animals is previously prepared by digestion, which is accomplished by organs peculiar to that kingdom. In this process of digestion, the animal destroys the organic substances and then throws off by respiration, excretions, &c., the rude substances on which vegetables subsist.

Again, their respiration is entirely different. Animal respiration is performed without intermission during life; while light is indispensably necessary to the respiration of plants. If this fact had received the attention to which it is entitled, much of the difficulty attending the examination of the fovilla chara, and other plants, which appeared to exhibit signs of animal life, would have been avoided, and the boundary between the two kingdoms settled much earlier. The small movable chemical compound found in these vegetables, resembles the *infusorial animalcula*, and it was believed for a long time that they constituted the connecting link between the two

kingdoms, and were in fact of both vegetable and animal character, and possessed the functions of both. More recently, however, it has been ascertained that their action or motion is regulated by light, and is wholly dependent on it, and that when it is withdrawn they become stationary, thus resuming their vegetable character. This motion appears to be the act merely of germination, effected under the influence of light, as the germs never exhibit the phenomena the second time.

This phenomena is explained by Professor Henry, in a very satisfactory manner, and we will give his views in his own language. "In certain parts, probably, of all plants, are found peculiar spiral filaments, having a striking resemblance to the spermatozoa of animals. They have been long known in the organs called the antheridia of mosses, hepaticæ, and characeæ, and have more recently been discovered in peculiar cells on the germinal frond of ferns, and on the very young leaves of the buds of phanerogamia. They are found in peculiar cells, and when these are placed in water they are torn by the filament, which commences an active spiral motion. The signification of these organs is at present quite unknown; they appear, from the researches of Nägeli, to resemble the cell mucilage, or proto-plasma, in composition, and are developed from it. Schleiden regards them

as mere mucilaginous deposits, similar to those connected with the circulation in cells, and he contends that the movement of these bodies in water is analogous to the molecular motion of small particles of organic and inorganic substances, and depends on mechanical causes."

But leaving this vexed question, we pass to the respiratory organ, which we find is different in each of the divisions of the vegetable kingdom, and also in the different grades of animal life. We will also find that each one of these organs is admirably adapted to the organism in which it is found. In man it is so constructed, that besides ministering to the oxygenation of the blood, its primary office in the economy of life, it becomes the instrument of voice and expression, two properties which have relation to his intellectual nature. The apparatus required for adapting the organ of breathing to these superadded endowments, is altogether different from that which is found in the lower animals, where the organ is subservient only to the purification of the blood. As a correspondence must exist between the structure of the different moving parts of the frame, and the nervous system which regulates the action of the body, the change in the construction of the organ is accompanied with a change in the arrangement of the nerves. Accordingly, a distinct class of nerves

is appropriated in the human frame to the organ of respiration, called the respiratory nerves.

Sir Charles Bell made a very careful examination of the nerves arising from the *medulla oblongata*, and found that they were all distributed to those parts, which, together, form the organ of respiration. The *portio dura* is sent to the nostrils and mouth, and to the exterior orifices of the tube which leads to the lungs. The *glosso-pharyngeol* goes to the posterior openings of the nostrils, and to the upper part of the windpipe. The superior and inferior laryngeal nerves, branches of the par vagum, supply the larynx, which is the organ of voice. The par vagum then descends into the chest, and is distributed chiefly to the windpipe and lungs; but branches of it extend to the heart. The spinal accessory nerve is sent to the muscles of the shoulders and neck, which combine with those of the chest in dilating the lungs. This mechanism is very different from that found in lower animals; and the reason is obvious. In the lower orders of animals the organ is limited to one function, that of oxygenating the blood, while in man it becomes the organ of voice and the instrument of articulate language.

To regulate the action of the superadded mechanism, a new and distinct class of nerves becomes necessary. Something certainly, which must have been

provided and adapted to their office by a wisdom which foresaw the necessity of the various parts. On an examination it was found, that the new and distinct nerves were necessary and indispensable to man; but that they were not so in the organization of the lower animals. In the higher organization, the first essential thing is, that the air for oxygenating the blood be received into a closed cavity, communicating with the external atmosphere by a single tube; the second is, that this cavity be capable of contracting on the volume of air within, so as to expel it along the tube with sufficient force to produce sound. This formation is never found in animals. No traces of a true chest and windpipe are found below the class vertebrata. In the lower animals there is neither circulating system nor distinct respiratory organ. The first or lowest animal respiratory organ is merely a few prolongations of the integument of the animal in the shape of tufts or fringes, which float in the water, and thus expose the blood to the oxygen contained in that element. The Polype is an example of this class. The next formation of this organ is in the shape of small sacs within the animal in which the integument is folded inward upon itself. The apparatus in many insects is a modification of this structure. Ranged regularly along the sides of their bodies, there is a succession of holes, which are

the openings of a series of small tubes extending through their interior, by which means the air communicates with the blood. The next organization is that of the branchial or gills, found in fishes. Here we first find the mouth connected with the respiratory organ. This connection requires a new organization to expand and compress the chest, that the air may be received into and expelled from the chest. As we advance in the scale of animal existence, we find a new apparatus of singular importance. This is a partition between the abdominal and thoracic cavities, which stretches across from the lower border of the ribs on one side to the other; and is known as the diaphragm. It circumscribes the space which contains the lungs, and thereby gives greater force to the expansion and contraction of those organs; and acts as a powerful muscle of respiration in dilating the area of the chest. This organ is not found below the class mammalia; nor is it needed in the lower classes. It acts with the most perfect harmony in connection with the superadded nerves found in man; and it is by their combined and harmonious action that he is enabled to produce vocal sounds and articulate language. The respiratory mechanism of man corresponds with his superior endowments, and supplies him with an organ adapted to the great purposes of communicating thought and evolving the

powers of his mind; the attribute by which he holds his exalted position in creation.

According to Plato, in his "Protagoras," the ignorance of Epimetheus would have left man "naked and unshod, unbedded and unarmed," had it not been for the kindness of Prometheus, who stole the artificial wisdom of Vulcan and Minerva for him, which, together with fire, gave him a divine condition, and enabled him to protect himself from the severity of the seasons and the ferocity of beasts. But he was not entirely superior until he had learned to articulate sounds and words, and received the gifts of "Shame and Justice" from Hermes, the authorized agent of Jupiter. In physical power he cannot compare with the animal that bears his burthen or does his bidding. In these particulars the ox is his equal, and the ass his superior. Without these intellectual attributes he would be the weakest of all animals, and exposed to the attacks of the whole catalogue of carnivora; but with it his weakness becomes strength; and the fiercest and wildest animals are subjugated, and all that are really necessary are forced into his service.

Having been led in our remarks on the respiratory organs to notice the adaptation of the nerves, we will now invite attention to that subject in a more general way. The circulating system is effected also, by the

superadded mechanism of the higher animals. As the respiratory organ approaches the perfection which it attains in man, the blood-vessels are divided into two distinct systems; the one for purifying the blood, and the other for distributing it over the body. Some of the most beautiful adaptations in the human system are connected with the circulation of the blood. As the act of respiration momentarily obstructs the flow of blood into the veins, if it be strong, regurgitation may be the result. It is obvious from this, that the veins may become congested, and be in great danger of serious injury. The veins of the head leading to the brain and eyes, are protected from these dangers by an arrangement of the muscles of the neck, which cover and protect them. These muscles combine, in sympathy with the movements of the chest, so as to compress the veins where there is a tendency to regurgitation, and to remove the pressure when the chest is expanded. The *orbicularis*, which covers the eye, is a part of the same provision. It compresses the eye-ball when the chest is violently contracted; by which means the veins at the back of the orbit are closed, preventing ingorgement of the fine branches which ramify on the delicate coats within. This is a distinct provision to protect the eye from the danger of engorgement by violent respiration; for this muscle is not found in

animals, where the respiratory organ acts feebly. There is a second beautiful arrangement to protect this delicate organ from engorgement or violent circulation, to which we must allude. The veins which ramify in the interior of the organ, between the delicate membranes that support the retina, make a cir cular sweep previous to entering the principal vein. This admirable structure breaks the force of a retrograde current of blood, and gradually diffuses it over the membrane.

We have given a few only of the many striking adaptations in the animal kingdom, which prove the intelligent action of the creating Power. We cannot avoid alluding to another evidence of this character, partly on account of its peculiar force, and partly because it has been referred to for the same purpose by the distinguished professors, Owen and Whewell. In the case of the kangaroo, the young animal is removed while very small from the womb to the pouch in which the teats are, where it is placed with its lips against one of the nipples. The young animal, however, is not so large as the nipple, and therefore cannot suckle in the usual manner. This difficulty is overcome by an appropriate *contrivance*, which clearly proves original design. The nipple is provided with a powerful extrusory muscle, by which the mother can inject the milk into the mouth of her

offspring. This muscle is not found in any other animal. To support or give attachment to this muscle, a new bone is necessarily introduced. Another difficulty, however, presents itself. What is there to prevent suffocation, when the milk is injected into the mouth of the young animal, without any muscular action on its own part? This difficulty is avoided by another singular but appropriate contrivance. There is a funnel in the back of the throat by which the air-passage is completely separated from the passage for nutriment, and the injected milk passes in a divided stream on each side of the larynx to the œsophagus; this prevents suffocation until the young animal is large enough to get along without it, and then it disappears.

But, not only by these appropriate contrivances and beautiful adaptations, are we taught the error of these theorists, but by evidences of the impossibility of any transmutation of species. In the animal creation, as in the vegetable, there are distinctions between the various departments and classes, which forbid the idea of any connection. To take an obvious instance, there is no middle class or department between the vertebral and the invertebral animals. In the vertebral the mass of the nervous system is included in a long cavity extending from the head down the hollow of the spine, while the bony parts

are internal. In the invertebral, the nervous cords run along the abdomen, and under the viscera; not above, as in vertebrals; while the hard parts are external. But it is useless to point out distinctions; there are in fact few, if any, parallel points. Each class and order is distinct from every other. So true is this, that the genus, and frequently the particular species of a fish, may be told from the examination of a single scale. A bone, taken from any part of a skeleton, is generally sufficient to enable a skilful osteologist to distinguish the genus of the animal. Indeed, a single tooth will enable the son of science to distinguish the division of the mammal to which it belonged.

Such marked distinctions, extending as they do, into the minutest parts of the animal, are incompatible with the theory of development, or the idea of transmutation. They are wholly irreconcilable with it; because many of the distinctions are not indispensably necessary to the particular form in which they are found, and because they could not have resulted from any desire of the animal, or any disposition to accommodate itself to the surrounding circumstances.

But we return to the differences in the respiration of the two kingdoms, which exist not only in the formation of the respiratory organs, but also in the result of their respiration. Animals are constantly

throwing off carbonic acid, which is necessary to vegetable growth, while the vegetable kingdom supplies animals with oxygen, which is equally important to their existence. They are thus reciprocal in their offices of kindness, and by their mutual exchanges contribute to the life and growth of each other. Decomposed animal matter aids the growth of plants; and these in their turn support animal life. By vegetable mould the wasting action of running water is compensated in some degree, while the valleys are enriched, and the rents and chasms are filled up by their deposit.

Finally, in concluding our remarks on this subject, we may add, that there appears little or no analogy between the two kingdoms of animate nature in the actions of nutrition and respiration; and certainly none can be found in the organic apparatus which performs these functions. As none exists between the two kingdoms, or any of their members, so the members of each are distinct and independent in their organization. As we have just seen, the different products of their labor enable them to make continual exchanges with each other, by which means they secure a counterbalance, and maintain an admirable equilibrium in the midst of the disorder which seems inevitable, but which is never permitted to take place in the harmonious action of nature.

Reciprocity, mutual exchange between the various members of this mighty family of organisms, is one of the first laws of life, written on matter by the stern hand of necessity. And in its operation we find all that is beautiful to the eye and dear to the heart. This connecting link, running as it does, through the whole of created matter, binding each separate body, and all the primordial elements in relations of dependency, is not only the triple tie of nature, but the beginning and source of innumerable blessings. Through this law, strength becomes the protection of weakness; age of infancy; and wisdom and purity are driven to the rescue of ignorance and corruption. The beautiful and tender relations of the domestic circle; of husband and wife; of parent and child; in which the noblest affections of our nature are engaged, and our chief enjoyments are found, and all the ties and obligations of society, depend on and result from this law. In nature or the inanimate world, this law is equally important. Mountains are forced up by the igneous agencies within our globe; and rearing their lofty peaks into the colder regions above, carry up the floating vapors of the atmosphere, where they are condensed into rain and snow, which are precipitated on the valleys beneath them. These waters wash away portions of the soil, and would, if

alone in their action, speedily change the surface of our globe; but their influence is counterbalanced by the igneous agencies and the vegetable deposit, and thus all serious changes are avoided. The distant portions of the earth are forced into exchange by the diversity of climate; and the ocean, by which they are separated, has been adapted to facilitate communication between them, and made the means of knitting them together by the ties of commercial reciprocity.

Thus, although the various organisms do not spring from each other, they are bound to each other in the most intimate relations, by an unalterable law, which is not only the means of their continued existence, but the foundation of their happiness. He only who is unable to discover the grandeur and beauty of the relation, and the wisdom of the great PRIMARY CAUSE, is without the mighty circle which is cheered by the presence and warmed by the goodness of the CREATOR, and is not likely to share its ultimate blessings.

> "Happy is he who lives to understand—
> Not human nature only, but explores
> All natures—to the end that he may find
> The law that governs each; and where begins
> The union, the partition where, that makes
> Kind and degree, among all visible beings;
> The constitutions, powers, and faculties,
> Which they inherit—cannot step beyond

And cannot fall beneath; that do assign
To every class its station and its office,
Through all the mighty Commonwealth of things;
Up from the creeping plant to sovereign man.'

PART V.

PHYSICAL GEOGRAPHY.

I.

Within a short period of time, many of the important questions which perplexed the savan, and alarmed the theologian, have been settled. Phenomena profound and mysterious, extending from the microscopic world of wonders to the more astonishing revelations of the telescope, have yielded to the successive steps of knowledge. New and interesting territories have been brought within the dominion of mind by the increase of instrumental power; and scenes of grandeur and beauty spread out before us, tending to elevate and ennoble our conceptions of the great and beneficent Architect, which is the natural and inevitable result of all faithful, scientific inquiry.

If we except Astronomy, no branch of knowledge

has been more rapidly advanced within the last quarter of a century, than that connected with the physical geography of the globe we inhabit. In the apparently irregular figures and careless distribution of the continents, in which Paley could discover no evidences of original design, science has detected a systematic arrangement, sustaining a most intimate relation with all terrestrial phenomena, and highly important in the diffusion and development of vegetable and animal life.

Independently of the relations our planet sustains to the celestial bodies in the economy of the solar system, it is significantly marked with the evidences of harmony and design. And it matters not whether we contemplate the figures, division, and distribution of its continents; the position and adaptation of its fertile valleys; the character and arrangement of its mountain chains; the number and chemical affinities of its constituent elements; its atmosphere, orbit, axis, or rotary motion; upon all, the same impressive lessons have been written.

The earth is an oblate spheroid, varying in its equatorial and polar diameters about one three-hundredth part of its greater diameter, or a little more than twenty-six miles. Whether this is the figure a fluid mass would naturally assume when revolving around a centre, is a question not necessarily con-

nected with our subject. This difference in the equatorial and polar diameters, the existence of which has been demonstrated by various methods, is comparatively small, but is, notwithstanding, a very important element in the economy of our globe. By it the solar rays are unequally distributed, and the temperature of the greater zones of the astronomical climate secured. Thus, in the earliest period of the world's existence, in the morning of its creation, according to the prevailing opinions and theories, we see the evidence of an intelligent and designing primary CAUSE written out on its spheroidal figure. And it is not important, so far as the inquiry itself is concerned, whether the centrifugal force of the revolving fluid mass was the agent employed to secure it, which appears most probable, or whether it was effected by abrasion and deposit, or by internal upheaving forces, it is necesary in the economy of the world, and must have been designed to perform its part, and adapted to the physical relations it sustains.

The spheroidal figure of the earth is connected with its diurnal revolution. The reciprocal attraction of the component particles of a fluid mass at rest, would produce a *sphere;* but the earth is not an exact sphere, therefore, it is not at rest. This is not the only, and perhaps not the most satisfactory evidence of its motion. "It is," says Sir John Herschel,

" in accordance with all the phenomena of the apparently diurnal motion of the heavens ; and, as they are explained by the supposition of the earth's rotary motion, it has been adopted." To this motion of the earth we are indebted for an alternation of light and darkness, of labor and rest, corresponding with our physical necessities. It is also an indispensable element in the complex machinery by which the solar heat is measured out in due proportions to the various sections of our globe. This motion, and the effects of it, are more particularly described in the preceding section on " Astronomy," to which the reader is referred.

The surface of this elliptical planet of ours is differently affected by, as it is unequally exposed to, the solar rays, and therefore it has been divided for convenience, into various zones of temperature. These would be uniform, were it not for the modifying influences in nature, such as the contour and geographical distribution of the continental masses, and the terrestrial elevations or reliefs ; which, in connection with the oceanic and aerial envelopes, secure, through the instrumentality of the infinitely multiplied physical laws, those important modifications of temperature upon which the beauty and usefulness of so many sections of our globe depend.

" The temperature," says Baron von Humboldt,

"is raised by the proximity of a western coast, in the temperate zones; by the divided configuration of a continent into peninsulas, with deeply-indented bays and inland seas; the prevalence of southerly or westerly winds: chains of mountains acting as protecting walls against winds coming from colder regions; the vicinity of the oceanic current, and the serenity of the sky in summer; and that it is lowered by elevation above the seas, when not forming part of an extended plain; the compact configuration of a continent having no littoral curvatures or bays; the vicinity of isolated peaks; mountain chains, whose mural form and direction impede the access of warm winds; and a cloudy summer sky, which weakens the effect of the solar rays." With a knowledge of these interesting and important facts (for which science is chiefly indebted to that most extraordinary man, to whose inherent love of knowledge, and philosophical observations, the secret chambers of nature seem to have been opened), we proceed to trace the distribution of these modifying agents. In them we shall be able to discover more perfectly and distinctly, the original design of the INFINITE AUTHOR.

By casting your eye over a correctly-marked globe, you will discover that a large proportion of the continental element lies north of the equator, and that the oceanic element greatly predominates on the southern

side. Humboldt says, the area of the solid is to that of the fluid parts of our globe, as one to two and four fifths. In round numbers, there are thirty-eight millions of square miles of land; two thirds of which lie north of the equator. From the fortieth degree south latitude, to the Antarctic Pole, the earth is almost entirely covered with water. "The fluid element predominates in like manner between the eastern shores of the old and the western shores of the new continent. The southern and western hemispheres are, therefore, more rich in water than any other region of the whole earth." Here we see the proportion and distribution of the two elements; but there is a third as important as either of these; the atmosphere, "an elastic fluid," by which both of the former elements are surrounded. Through its agency, the reciprocal action of the land and sea is effected. It constitutes the connecting link between them, by conveying the vapor of the one to the mountain chains and isolated peaks of the other, where it is collected and forced down their declivities, or condensed and precipitated on their slopes and intervening valleys, in the form of rain and snow. The climate of a country, therefore, is not the result solely of its geographical location, but depends on the relative extension of the solid and fluid parts of our globe, and their action upon each other, which is variously

affected by the terrestrial reliefs and local compensations.

Leaving these for the present to trace the distribution and configuration of the continents, we find that the eastern hemisphere has a much larger area of elevated land than the western, and that it has its greatest expansion from east to west, while the new continent has its greatest length from north to south. But notwithstanding the difference in the position of their major axis, there is a remarkable regularity in the general figures of the continents, and in the arrangement of their reliefs, which seem to have been thrown up by some determinate power. We are indebted to the German physicists for much of all that is known of the analogies which exist between the continents; or, at least, for calling attention to them; and particularly are we indebted to Baron von Humboldt and Professor Guyot. The latter, by pointing out the remarkable adaptations in the relative expansion of land and water, and in the distribution, figures, and reliefs of the former, has converted "Science into a Christian teacher."

It has been remarked that the continents are arranged in pairs, lying north and south of each other, and united together by a narrow isthmus. Although this is not strictly true, there is sufficient evidence to justify the remark. North and South

America sustain this relation to each other, but in the continents of the old world, Europe and Africa only are connected in this way. Asia and Australia have a chain of islands between them, which may be considered as the elevated points of the connecting isthmus, the remainder being submerged. The next analogy presented in the different continental masses is the group of islands found east of their most southern points. "America has the Falkland Islands; Africa has Madagascar and the Volcanic Islands, which surround it; Asia has Ceylon, and Australia has the the two great islands of New Zealand." A third analogy is marked by a deep inward curve of their western coasts. In America this inflection takes place along the coast of Bolivia; the Gulf of Guinea represents it in Africa; in Asia the Gulf of Cambaye and the Indo-Persian Sea; and in Australia it is seen in the Gulf of Nuyts. However forced these analogies may appear at first view, it will be found on examination that they nevertheless do really exist.

There are, then, three pairs of continents; two in the old, and one in the new world; and these are divided into northern and southern members. Those of the south resemble each other, and the same may be said of the northern members; but the northern differ very materially from the southern. These

differences or diversities are of the greatest importance. As the physical distinctions and varieties existing between the oceanic and continental elements, by acting and reacting on each other, secure not only many important compensations in nature, but by giving life and vigor to each other, make one entire and perfect whole; so the great variety of soil and climate enables the continents not only to relieve the poverty, but to increase the resources of each other, by a mutual exchange of products. The northern continents are uniformly wider than the southern, and attain their greatest expansion in the Arctic circle, becoming more and more narrow as they approach their southern associate. The southern continents, following a similar law, are widest at the north, and continuing to narrow as they approach the southern pole, finally terminate in high and rocky points. Cape Horn, Cape of Good Hope, Cape Cormorin, and the Australian Cape, south of Van Dieman's Land, are instances of their southern terminations. To this general arrangement of the continental forms there is no exception.

The northern continents contain nearly two thirds of the continental area; according to Professor Guyot, they contain twenty-two and a half millions of square miles, while the southern contain sixteen and a third millions only. In tracing the charac-

teristics of each, we find the northern more indented, more articulated, and their contours, therefore, more varied. They are also enriched by inland seas and gulfs. The southern are more compact, have fewer indentations, and no inland seas. The northern continents, therefore, are more maritime, more commercial, and infinitely better adapted to the development of the physical and intellectual powers, and social character of man. They are also nearer to each other, which encourages and secures a constant communication between them. The southern are smaller, and are widely separated from each other, and appear designed to act a less important part than the larger and more highly-favored continental masses with which they are connected. The northern continents are almost entirely in the temperate zones, while the southern are confined to the tropical and warm temperate zones. To these peculiarities of form, location, and relief, their characters must be ascribed; not to any particular one of them. Their mutual action is as indispensably necessary in the operation of the vast machinery, which may be called the economy of the intellectual and moral development of man, as the concurrent action of land and water, and heat and cold, is to the constitution of a healthy and invigorating atmosphere.

Their mountains are symmetrically arranged, and

by their direction, height, and escarpments, materially influence the temperature of the continental climates. The principal chains of the old world follow the direction of the parallels; while those of the new world take the direction of the meridian. The law, as in the case of the major axis, seems to be entirely different in the eastern and western continents; but in other matters the same economy is observed. The highest elevations of the continental masses, following the direction of the mountain chains, are uniformly located on the sides of the continents, and not, as might be expected, at the centre. The mountains descend gradually towards the Atlantic and Frozen Oceans; while their slopes are rapid and precipitous towards the Pacific and Indian Oceans.

"If this order were reversed," says Professor Guyot, "and the elevation of the lands went on increasing toward the north, the most civilized half of the globe at the present, would be a frozen and uninhabitable desert." This disposition of the slopes is most uniform and remarkable. There is nothing in the formation of the continental masses better adapted to impress the mind with the idea of original design. Admit that the upheaving force resides within our globe; that the irregular but ever active motion of the disturbed molten element at the centre,

acting directly on the surface, produced these elevations; yet how came this power to act so uniformly and regularly? How came the slopes and greatest elevations to be so perfectly adapted to the form and configuration of the continents, and to their various climatic relations? The highest elevations are found near the tropics; as the Himalaya in the twenty-seventh degree north latitude; and Nevado de Sorato, in the sixteenth degree south latitude. The question naturally arises: Why are the greatest elevations on each side of the equator, and their distances from it, so nearly corresponding to each other? There is no physical law by which this question can be answered; but herein we notice a most remarkable fact. It will be seen hereafter in our remarks on the oceanic element, that the greatest proportion of salt in the Pacific is in the parallels of nearly the same latitudes; and that the saline principle increases gradually from the Poles to those points. These arrangements must have a connection with the climate, and must have been so ordered to lower the temperature thereof; for such is the effect of both.

The continental masses, however, rise, as indicated by their slopes, gradually from the north and south, to the equator. The mean elevations of the northern and southern divisions most clearly establish this fact. Owing to the difference in the density of the

atmosphere at different altitudes, on which its capacity for heat, and its radiating power depends, the temperature of the lower strata is always higher than the upper. This atmospheric law has been observed in the elevation of the southern continents. By this means the extreme heat of the equatorial regions is greatly modified. But this is not the only element made use of in effecting that important object. Baron Von Humboldt estimates the mean relief of Europe at six hundred and seventy-one feet; that of Asia, at one thousand one hundred and fifty-one; that of North America at seven hundred and forty-eight; that of South America at one thousand one hundred and thirty-two; and that of Africa still higher. But the mean elevation of Europe depends in a great measure on the vast plains of Russia and Poland, the massive plateau of Spain, and the Alpine chain. That of Asia is greatly increased by the elevation of her southern table-lands. Those of Thibet, which commence with an elevation of four thousand feet, and rise as they approach the south to the height of nearly twelve thousand feet; and those of the Deccan, which, commencing with an elevation about equal to the northern portion of Thibet, run into, and are connected with the southern termination of the peninsula, which has an elevation of more than seven thousand feet above the level of the sea.

These elevations and slopes are not only adapted to the astronomical climate, and the distribution of the fluid element, which clearly indicate an intelligent arrangement by the Creative Power; but where their general disposition would produce an effect different from the one we now see, and which appears adapted to the best interests of our race, its influence is controlled by special and local compensations. Thus, in the case of North America, the effect of the long northern slope, by which we are exposed to the polar currents of wind, and the influence of the Rocky Mountains, which turn these currents back upon the Mississippi Valley, is controlled in a great measure by the action of the immense chain of lakes on the north, over which these currents must pass, and the Gulf of Mexico on the south. This deep cut, as observed by Professor Guyot, opens the southern portion of our continent to the wet winds of the tropics. The return trade winds, coming directly from the sea, water the Atlantic coast, the western slope of the Alleganies, and the Valley of the Mississippi. Owing, therefore, to this "broad gate," we are more highly favored with rains than could be expected from our situation and continental reliefs. A different disposition of the Rocky Mountains would change the character of our climate and country. The Rocky Mountains and Gulf of Mexico act and reäct

on each other, and are equally necessary in making up our continental character.

The longest slope of the Andes—which is one thousand eight hundred miles long, is eastward in its direction, and is abundantly watered by the trade winds of the Atlantic. The shortest, which is only seventy miles long, is to the west, and embraces the desert of Atacama. "Deprived of the vapors of the Atlantic by the Andes, these countries, (embracing the coast of the Pacific from Peruta Pariña and Amatope to far beyond the tropics, from the equator to Chili,) behold the vapors of the Pacific flitting away with the trade wind, and no accidental breeze to bring them back." Brazil and Guiana are indebted to their secondary chains for their irrigation; while Peru and New Granada are saved from the condition of Atacama by a depression of the Cordilleras. A similar depression, acting in conjunction with the continental form, secures a sufficient irrigation to Chili, by deflecting the trade winds. Thus we see the effect of mountain chains, with their depressions and curves; and how general laws are influenced and controlled by local arrangements; by which territories, which otherwise would be useless, are fertilized and redeemed for the use of man.

Western Europe is indebted for the uniform temperate climate, which dintinguishes it from all other

countries in corresponding latitudes, to its numerous seas and inland bays and lakes, its mountain chains, and its location on the western side of the great continent. The Alps, Pyrenees, Appennines, Carpathians, and Ural chain; and the mountains of Sweden and Norway are so arranged as to protect the interior, while they contribute to keep the atmosphere humid and mild, by condensing the vapor so bountifully supplied by the ocean, Mediterranean, Black, Baltic, Adriatic, and North Seas. The water on the north, free from ice, modifies the cold winds from that direction; while its configuration opens its western coast to the elevated temperature of the Gulf-stream. Its atmospheric temperature is also elevated by the heated currents of air rushing in from the tropical regions of Africa. This combination of influences, to which western Europe is largely indebted, change its astronomical climate, and give it one which, notwithstanding its humidity, is almost unrivalled.

Sweden is a striking illustration of the influence of terrestrial reliefs. It lies between the fifty-fifth and seventieth degrees north latitude; but it is protected from the northern currents of wind by its mountain-chains; while its atmospheric temperature is greatly elevated by the waters or evaporation of the Baltic Sea and the Gulf of Bothnia on the south. It is owing

wholly to these facts, that they are enabled to cultivate the *cereals* so far to the north. It will be seen, from what has been said concerning the influence of the fluid element, that it tends to lower the mean annual temperature between the tropics, and to raise it in the higher latitudes; which will be explained hereafter. The climate of the two worlds, the old and new, and of each continent, is the result of all the general features of configuration and relief; which, we have seen, are adapted to the continental masses and their astronomical climate.

The northern continents, except Asia, have a comparatively low, mean elevation, although embracing immense elevated plateaux and mountain chains; the first of which, together with the continental masses themselves, rise as they approach the south; while the southern divisions, including Asia, have a high mean elevation. The necessity of this difference arises from their astronomical climate, and the atmospheric law of temperature to which we have alluded. But there is no physical cause for it. It is not connected with the elliptical figure of the earth; nor did it result from the same cause. If so, the southern continents would present slopes corresponding with those of the northern. It may be possible that these differences were caused by forces similar to those now acting on the coasts of Sweden and Finland;

but if this be true, their uniformity and importance, teach us that the agent thus employed, was obedient to some intelligent power to whom the concurrent influence of the various physical laws was foreknown. Sir Charles Lyell has most satisfactorily shown that continents and islands, having the same shape and relative dimensions as those now existing, might be placed so as to occupy either the equatorial or polar regions; and it is equally clear that there is no physical cause for their present arrangement. But the necessity of the arrangement seems to be written upon every spear of grass, and opening flower, and breathing animal. Not a single island could be removed from the wide expanse of the ocean, without affecting the atmosphere, and no great continental change could take place, without writing its history in a change of vegetable and animal life. The elements would herald any change in the continental relations, with telegraphic speed, to the uttermost parts of the earth; and sad indeed would the records of that change be. Yet, according to the best interpretion of geological phenomena, many of these changes have taken place in the preceding ages of our planet, the only history of which is written in the hieroglyphics of the generations sacrificed by the changes, and buried in the strata to which they belonged. All the way up from the depths of the earth, these

evidences are found; thus coustituting a history written by the worm, the insect, and the fish, melancholy, indeed, yet more ancient and truthful, than any ever written by man. But their interpretation is due to his superior mental endowments, by which he is enabled to collect the scattered leaves of these dumb historians, and weave them into a mighty and mysterious volume.

This uniform elevation in the torrid zones, and depression of the surface at other localities, redeems large territories from the astronomical climate. In the torrid zones, where, without it, the earth would be a parched or dreary waste, a richness and variety of vegetable life is found, to which we are strangers. "Thus," says Humboldt, "it is given to man in those regions to behold, without quitting his native land, all the forms of vegetation dispersed over the globe, and all the shining worlds which stud the heavenly vault from pole to pole." But he adds most appropriately, "In the frigid north, in the midst of the barren heath, the solitary student can appropriate mentally all that has been discovered in the most distant regions, and can create within himself a world as free and imperishable as the spirit by which it is conceived." No one knows or has felt these truths more deeply than himself. He who envies the sons of the luxuriant South, may turn with pleasure to this

glorious compensation, and thankfully enjoy that which Providence has provided.

The great Mexican plateau, although under a tropical sun, is blessed with a climate equal almost to that of Western Europe. A single day's journey from Vera Cruz, which is situated in the *Tierra Caliente*, enables you to reach the regions of perpetual spring. The same arrangement is observable in the plains of Colombia in South America. "The contrast," says Arnott, "is very striking, after sailing a thousand miles up the level river Magdalena, in a heat scarcely equalled in the plains of India, all at once to climb to the table-land above, where Santa Fe de Bogota, the capital of the republic, is seen smiling over interminable plains that wear the livery of the fairest fields of Europe."

Our first glance at the terrestrial surface, revealed the two great divisions of land and water, and their unequal distribution. Our next, the forms and relations of the continents; and our last, the effect of the elevations and local compensations. The necessity of each of these will more fully appear as we trace the phenomena with which they are connected. But the cause of these important divisions, forms, reliefs, and connections, is inferential only; and must be learned, if learned at all, from their importance in the economy of nature, and their mutual and reciprocal

agencies, which so harmoniously work out the great objects of their creation and arrangement. The elliptical figure of the earth is explained by its rotary motion; but not so its continental divisions and contours.

"All that we know regarding this subject," says Von Humboldt, "resolves itself into this one point, that the active cause is subterranean—that the continents did not rise at once in the form they now present, but were, as we have already observed, increased by degrees, by means of numerous oscillatory elevations and depressions of the soil, or were formed by the fusion of separate smaller continental masses." The geological formation of the earth's crust—the wide diffusion and elevated position of fossil shells, fishes and marine plants, and the present active forces exhibited on the coasts of Sweden and Finland, induce the belief that the process of elevation was gradual. And the existence of fossil plants and animals in northern portions of our globe, whose nature required a much warmer climate than the one in which they were found, favors the opinion that these upheavels have been sufficiently great to change the character of the continental climate.

But when were these mighty changes effected? For more than two thousand years the earth's surface and size have not materially changed. If the whole

mass were growing less by the gradual escape of internal heat, and consequent shrinking of the bulk, or from any other cause, the time occupied in making a revolution on its axis would also change; but this has not been the case. La Place, who contributed as much to the annals of science as any one since Newton's time, and whose only rival, as remarked by Professor Playfair, was the genius of the human race, concluded from the comparisons made during the period in which history has kept record of these matters, that the sidereal day has not changed as much as one three hundredth of a second since the time of Hipparchus. And notwithstanding all the violent shocks of earthquakes to which Greece has been subjected, and all the changes, if any, which the internal forces have produced, the springs of Hellenic antiquity are still found at the same places. Erasinos, south of Argos, still refreshes the weary traveller; Saint Nicholas flows on beneath the temple of Apollo, as of old; the crystal waters of Castalia still murmur in the shades of Phædriadæ; and the hot springs of Ædipsus, in which Sulla bathed, and those of Thermopylæ, at the foot of Œta, are used now as they were then. No change has disturbed the fountain from which they are supplied. Other localities, however, have experienced great changes. Rivers have been swallowed up, and mountains and volcanoes

have arisen in a single night, showing the power of the uneasy element within our planet. One instance of this character, which excited much attention at the time it occurred, is associated with one of the most melancholy histories of the age; in which, as it is too frequently the case, the innocent and lovely suffered more intensely and deeply than the unfortunate, though guilty relative, by whose crime they were buried in inconsolable grief. Like the island, the historian of Sabrina is no more. Like it, he rose above the surrounding elements, and, after attracting the attention, and enjoying the respect of the learned and great, like it he sank amid the tempests and billows, into the ocean below. The island of Sabrina, near St. Michael, which was about one mile in circumference, rose above the sea in a short time, to the height of three hundred feet, but sunk back again after enjoying the solar rays for a few weeks. Thank Heaven, its surface blushed not at the morning sun as it took its sad farewell; nor did it leave fond and loving kindred to mourn its untimely end. Nature is free from these sad partings; man makes them for himself.

Sir Charles Lyell has attempted to relieve us from the difficulties these questions present, by showing the high probability of vast but gradual changes in the continental masses, by which the climate of par-

ticular regions have been wholly changed. All this may be, and most likely is true; yet it does not affect the grand question involved. The uniformity of the continental arrangements, and the general and special adaptations of form and relief, together with the various physical laws, which we have thus far pointed out, as strongly persuade the mind that these beautifully adapted and necessary dispositions of land and water, of valley and mountain, did not result from the irregular and accidental force of indeterminate powers. And when we connect them with the form of the earth, its axis and rotary motion, and its relation to and dependence on the sun, we discover a vast plan of mutually adapted elements, which, however accidental in appearance, act in perfect harmony with the innumerable and profound phenomena of nature. This, if it were the only evidence, would be sufficient to convince the reflecting, that the continents took their places, forms, and reliefs, obedient to the mandate of a power without and above the physical agents, which are employed to do the behests of the Creator. The earth may be molten at its centre, and the continents and terrestrial reliefs may have been thrown up by the agency of those internal fires. It is as easy for the Infinite Creator to operate in one way as another. Everything, however, appears to, and does in fact, contribute to prove

the subordinate and determinate action of the various physical agents, in their great work of preparing the world for the habitation of man.

II.

THE GREAT CENTRAL SOURCE OF HEAT.

The Sun is the great central source of heat, as well as gravity. The vast and mysterious power it exerts in holding the distant planets in their orbits, is not more wonderful than the influence of its rays on the complex machinery by which the atmospheric temperature is regulated, and the uniform action of the laws of vegetable and animal life maintained. By it the winds are produced, and the heavens kindled with those electric displays, which are fearfully beautiful, but, like all other natural agents, are indispensably necessary in performing their mysterious offices in the economy of the system. By the vivifying action of the sun, vegetable life is sustained, and upon it animal life depends. Under its influence the sea circulates in the form of vapor, supplying water to the continental element. The temperature of the various parts of the earth's surface is governed mainly by the exposure of those parts to the solar rays; that is, the time they are thus exposed, and the manner

in which the rays are received; whether vertically or obliquely. If the sun remain longer above the horizon of any place than below it, its temperature will increase; and so also will the temperature decrease if it remain longest below the horizon. We are nearer the sun during the winter than we are during the summer; the difference in the temperature of the seasons does not, therefore, depend on our variable distance from that luminary, but on the time the terrestrial surface is exposed to its rays, and the manner in which the rays are received. But this subject is fully explained in our chapter on Astronomy, to which we refer. These laws of adaptation are merely ministerial and secondary. The sun is the great agent; its vivifying power touches the universe, and gladdened nature with its thousand varied tones of deep, yet mild rejoicing, and its sweetly blending hues of varied beauty, fills the wide spread canopy with grateful and harmonious response.

"There is the sun's pavilion, whence arising,
Like a proud bridegroom, in his splendor drest,
And with glad light the dewy earth surprising,
A giant glad, he speeds him to the west.
His going forth is from the orient heaven,
And round he hies again to reach the goal;
The lowest earth feels his glad heat like leaven,
Working mysterious ends from pole to pole."

In connection with these laws, it will be found that the proportion and distribution of the solid and fluid parts of our globe also contribute to the general result. Professor Dove has shown that the mean temperature of the earth's surface is considerably greater in June than it is in December. The line of the sun during its perihelion passes over land less than one sixth part of its course; the remainder it passes over water. This arrangement has a very material effect on the mean heat, as shown by the professor. Land radiates the solar heat into the atmosphere much more rapidly than water. Water absorbs most of all it receives, while the land radiates it back into space. If this arrangement had been reversed, the proportion of land being the greatest under the sun's line during its perihelion, the whole climate must have been different.

Nearly the whole of the one sixth of land thus exposed, lies in Africa. The streams of warm air generated by the sun when passing over this part, have at some points only a short space to pass over the Mediterranean; and where this sea is broadest, it weakens the heating power of the south winds so little, that they are felt as a hot sirocco through all Italy, up to the Tyrolese Alps. The westerly parts of Asia to the middle degree of latitude, are warmed in

the same way, and especially the East Indian peninsula.

The mild climate of Western Europe, as we have seen, is largely indebted to the same cause. From the immense influence of this one sixth of land, we can calculate with a degree of certainty, how indispensably necessary is the present distribution of land and water. Here under the burning climate of the equator, water has a cooling effect; it absorbs the heat, and thus secures the atmosphere from that excess, which the land, if it predominated, would produce by radiation. The evaporation of the water also contributes to lessen the power of the sun's rays by the mists and clouds which it produces. In the operation of these laws, we cannot fail to discover the intimate relation and mutual dependence of the various agents in nature. No one can be changed without affecting the whole. The atmospheric temperature and the local climates, so essential to the growth of the different vegetables and plants, and to the full development of man himself, depend on the harmonious action and reaction of the various complex physical laws; on the elliptical form of the earth; its axis, and diurnal and annual motion; the depth, pressure, and expansive power of the atmosphere; the division, distribution, and configuration of the continents; the terrestrial reliefs, and the properties of the

oceanic element. The ocean supplies the vapor by which the continents are watered; but were it not for the tendency of its saline contents, the amount of vapor given off would be much greater than it is; sufficiently great, perhaps, to change the character of the whole atmosphere; and hence the laws of life. The saline contents diminish the tendency to throw off vapor, and also lower the point of congelation, and therefore tend to keep the seas liquid. Experiments were made by Bladh, Kirwan, and Doctor Traill, on the specific gravity of the water in different places in the ocean, by which it appears that the saline contents increased gradually from the Poles towards the equator. It has been ascertained, however, that the greatest proportion of salt is found in the parallels of the twenty-second degree north latitude, and the seventeenth degree south latitude. In this, as before observed, there is a singular agreement with the highest terrestrial elevations. Here is an agent almost concealed, but not less important than those stupendous continental reliefs which act so powerfully on the imagination and feelings of man.

The ocean supplies the vapors, the winds bear them over the continents, and the mountain chains forcing them up into the higher and colder regions, act as condensers. But in these changes the sun is the great primary agent; by it the winds are

created, and the vapor distilled from the waters of the ocean, which after performing various important offices to the vegetable and animal kingdoms, is again returned to the ocean to commence anew its unceasing circulation.

The oceanic element is much more constant in its temperature than the continental, and by communicating with the atmosphere above it, greatly modifies the climate of the latter. Water is not affected either by heat or cold, to the same degree with the solid portion of the globe. In the first place it is a less susceptible conductor; secondly, the evaporation, which increases in proportion to the intensity of the solar rays, has a cooling effect on the surface; and thirdly, the unceasing motion and exchange which is kept up between the upper and lower strata, by which the heat or cold, as it may be, is communicated to its whole mass, causes a more gradual change of temperature, while its depth prevents extremes of any kind. The daily illumination of the sun warms the ground to a very limited depth; while the same quantity of heat will penetrate, though with a decreasing intensity, many fathoms of water; thus the line of invariable temperature under the equator, is seven thousand two hundred feet below the surface. In the former instance the heat is condensed; in the latter it is diffused through the whole mass. It has

been estimated, that the difference between the heat thus communicated, is as one to one hundred. And it is owing to these laws, together with the greater transparency of the continental atmosphere, and the inequalities of the terrestrial surface, by which radiation is increased, that the land cools more rapidly than the water.

These differently heated surfaces have a proportionate effect on the atmosphere above them. Water gives out but little heat by radiation, while the land radiates the heat it receives freely into the surrounding atmosphere. The difference in the heat thus radiated, is in the proportion of thirty to one; that is, there are thirty times less heat radiated by the water than there is by the surrounding land. It is to this diurnal atmospheric disturbance, that we are indebted for our local winds and pleasant sea breezes. But the evaporation of the water acts more freely on the temperature of the air than its radiation does. And it is chiefly by this means that the oceanic element moderates both the heat and cold of the adjoining land, and contributes generally to equalize the atmospheric temperature.

These two elements, although intimately related to each other, are unequally distributed, and come in contact at their margins only. Another element is therefore required to effect the exchange between

them. The atmosphere is the medium and the winds which result from the disturbance of its equilibrium, are the agents employed for this purpose. The heated portions of air being lighter, rise, while the colder and heavier currents rush in to take their place, precisely as in the case of differently-heated particles of water in the ocean. This motion produces the winds, which are more or less violent in proportion to the amount of atmospheric disturbance. This law is most beautifully illustrated by partially opening the door of a heated apartment communicating with a cold space, and holding a burning taper to the crevice or opening. If held at the top, the outward direction of the flame will indicate the presence of a current of air passing from the apartment into the cooler atmosphere. If you move the taper down, the flame will become more and more upright, until, at the middle of the crevice, it will cease to be affected by either current. If now you continue to move it downward, the flame will be driven inward, thus showing that the heated air rises and flows out of the top, while the colder air enters at the bottom.

This exchange is carried on between the tropical, temperate, and polar regions. The temperature of the tropics is always higher than that of any other portion of the globe; hence the air is constantly ascending, while the heavier and colder particles of

the north rush along the surface of the earth to restore the equilibrium of the atmosphere. By this means, a constant interchange of air is kept up between the unequally heated sections of the earth's surface. Our local and irregular winds result from these atmospheric laws of temperature; but the permanent and regular currents, however, dependent on the disturbance of the equilibrium, are governed in their direction by the rotary motion of the earth and the difference in the velocity of the polar and equatorial parts. This difference results from the elliptical figure of the earth. The trade-winds and monsoons are governed by this motion. They, like all other winds, result from atmospheric disturbance; but in their case the disturbances are regular, as they depend on the action of the sun on the unequally exposed portions of the earth's surface. Here we again discover the importance of the elliptical form of our planet. These winds, so important to the commercial interests of the world, are not only created by the unequal exposure of the surface to the sun, which it causes, but their direction is determined by the different velocities which result from it. If the polar and equatorial velocities were equal, these currents would be simply north and south winds; but the unequal velocity changes them into a northwest and southwest direction. The equatorial portion of the

earth's surface has a much greater velocity of rotation than the polar; the polar currents are, therefore, unable to keep up with the equatorial motion. Thus the direction of the north polar current is changed to the southwest, and that of the south pole to the northwest. The same cause changes the direction of the upper or equatorial currents to the northeast and southeast. They arrive at the north and south with a greater velocity than the earth's surface has at those points, and are, therefore, in advance of its motion. To this fact we are indebted for the westerly winds of the North Atlantic.

The beneficial influences of these regular currents, and of the winds generally, cannot be estimated. Gratuitous accounts of the imaginary and wonderful, such as Dr. Thompson has interwoven with his more serious labors, are wholly unnecessary to excite a proper degree of interest in them. While such accounts amuse, and perhaps interest the general reader, they in some degree retard the progress of scientific inquiry. The winds restore the equilibrium of the atmosphere, upon the disturbance of which they depend; distribute the vapor of the ocean; protect the tropics from the intense heat to which those regions are exposed, and by conveying the heated air and vapor north, greatly modify the climate there. In fact, they are the principal agents in effecting all

important atmospheric exchanges, and in carrying out the various compensations on the surface of the globe. By them the burning climate of Africa, south of the equator, is relieved in December, January, and February, when under the vertical rays of the sun. During these months, cold currents from the Indies and upper Asia rush in to relieve these regions, while the reverse takes place when India and Asia are heated by the burning sun of the northern summer, and Africa is cooled by the southern winter. And so the winds of the west and south-west, which prevail in the middle latitudes, soften the temperature of the western coasts of Europe and America.

The trade winds, sweeping over the surface of the ocean from the Antarctic regions, first strike the coast of Chili in the parallels of thirty-five degrees south latitude, and advance along the coasts of Peru as far north as Cape Parina, when they turn suddenly westward, lowering the temperature of the regions through which they pass. Thus, as remarked by Baron Von Humboldt, in his "Aspects of Nature," the temperature of the Pacific on the coast near Lima is sixty degrees two minutes Fahrenheit, while in the same latitude, out of the current, it is seventy-nine degrees two minutes. Thus, it is found that this current lowers the temperature of the atmosphere through which it passes nineteen degrees Fahrenheit. Such a cur-

rent must have a considerable effect on the climate of an entire continent. In the equatorial regions, where the course of the temperature and winds is regular, that of the rains is equally so; and instead of seasons of temperature, which are there unknown, the inhabitants draw the distinguishing line between the dry and rainy seasons. "Whenever the trade-wind blows with its wonted regularity, the sky preserves a constant serenity and a deep azure blue, especially when the sun is in the opposite hemisphere; the air is dry and the atmosphere cloudless. But in proportion as the sun approaches the zenith the trade-wind grows irregular, the sky assumes a whitish tint; it becomes overcast; clouds appear, and sudden showers, accompanied with fierce storms, ensue."

In these phenomena we cannot fail to recognise a most important arrangement. And, although the effect of these inundating rains, in engendering the fevers of those countries, is most injurious, and, to many, fatal, the greater number protected by their influence will more than compensate the loss. When we recollect the immense influence of an interposing vapor in weakening the intensity of the solar rays, we may with propriety inquire, whether the thick vapor in which the inhabitants are enveloped, at the time when the solar influence is greatest, does not protect

them from dangers infinitely more to be dreaded than the endemical fevers, however fatal they may be.

These rains and winds are also indispensable to the vegetation of those regions. The quantity of vapor in the atmosphere depends on the intensity of the solar rays; it is therefore always more abundant in the tropical atmosphere. This is one of the causes of the luxuriance of the tropical vegetation. But were it not for the almost inexhaustible supply of water deposited in the rivers and lagoons of those regions, by the annual rains, the moisture in the atmosphere would be insufficient to supply the vegetable kingdom. A failure of rain in the temperate climates for a few weeks only will cause the greatest injury. Who has not often seen the parched and withered vegetation of our own country, in seasons of drought, with indescribable feelings of sadness, and watched the gathering cloud with thankfulness of heart? Thus we see the importance of the winds in effecting an exchange of temperature between the equatorial and polar regions, and in modifying the various climates of the earth. But if the capacity of the air were greater than it is, its temperature would be less easily affected by the solar rays, and this circulation, so essential to both hemispheres, partially if not entirely destroyed; while, if the capacity of the heat were less, the pleasant and refreshing winds, so important

in knitting together the various nations of the earth by the bonds of reciprocal beneficence, would become the most fearful agents of destruction. There is indeed a most intimate connection between the multiplied physical laws with which man has made himself acquainted; a perfect and unbroken chain, extending through and around the wide domain of the infinite Creator; and not a link in all this vast chain can be withdrawn or broken without a fearful disturbance of the whole.

The winds keep up the circulation in the atmosphere, and restore its equilibrium, and the oceanic currents, which in some degree depend on them, perform the same office for that element. By these currents the exchange of warm and cold water from the differently heated regions is effected. It is not our object to attempt to trace these or any other phenomena to their primary cause, further than it becomes necessary to connect them together, and show the mutual adaptation and concurrent action of the whole; much less do we desire to enter on controverted territory for the purpose of disputation; but with all due respect for authority, we suggest the possibility that too much importance has been given to the unequal temperatures of the tropical and polar seas, in explaining the oceanic currents. Much, undoubtedly, is due to the general tendency of fluids to maintain

an equilibrium, but we do not consider this "the more profound and irresistible cause."

If the rapidity of these deep currents cannot be explained by the motion of the winds, they must result from some cause more powerful than that by which the winds are produced. It is true the sun has a most powerful influence in warming the oceans. Under the equator, the line of constant temperature is seven thousand two hundred feet below the surface. The Gulf Stream maintains its elevated temperature for more than one thousand feet below the surface. But the atmosphere is more elastic, is easier affected by the solar rays, receives heat, not only from the rays as they pass through it, but by radiation from the earth. The water loses part of the heat it receives by evaporation and radiation, while the depth of the ocean prevents the solar rays from penetrating to the bottom. Thus the line of constant temperature is at variable depths. At fifty-five degrees eighteen minutes, south latitude, longitude one hundred and forty-nine degrees twenty minutes west, Sir J. C. Ross found it at six hundred fathoms; at forty-nine degrees seventeen minutes, south latitude, longitude one hundred and seventy-two degrees eighteen minutes west, it sinks to nine hundred fathoms; while at the equator the same distinguished explorer found it at the depth of twelve hundred fathoms. From these

examinations he arrived at the conclusion, that there is a belt or circle around the earth where the mean temperature of the sea obtains throughout its entire depth, which is about fifty-six degrees fourteen minutes south latitude. This, as he observes, constitutes a neutral ground. That portion which is heated by the solar rays imparts heat to the underlayers by an exchange of particles. The sun, therefore, cannot act so powerfully and promptly on the oceanic element as on the atmospheric. If then these phenomena result from the same cause (*i. e.* a disturbance of the equilibrium of the two elements), the oceanic currents would not be greater, more powerful, or rapid, than the atmospheric currents. But they are, and therefore must have "a more profound and irresistible cause" than the mere tendency to restore the equilibrium. For these reasons, we adopt the opinion of Baron Von Humboldt; that the oceanic currents depend conjointly upon various causes; on the tides; the duration and intensity of prevailing winds; the modifications of density and specific gravity which the particles of water undergo, in consequence of the differences in the temperature, and in the relative quantity of saline contents at different latitudes and depths; and lastly, the horary variations of the atmospheric pressure successively propagated from east to west, and occurring with such regularity in the tropics.

These currents have a great influence on the continental climates. The climates of Chili and Peru are, as we have observed, considerably cooled by the antarctic polar current of wind; but the entire effect is the joint result of the atmospheric and oceanic currents, which rush in from the same point. A branch of the equatorial current, after passing round Guiana and the Caribbean Sea, forces itself between Cape Catoche and Cuba into the Gulf of Mexico, and after making the circuit of the Gulf, passes out between Florida and Cuba, and continues its course, under a new name, along our coast as far as Newfoundland, elevating the temperature of the whole coast. This current is deflected from that point to the eastward, and finally reaches the coast of Africa. A portion of its warm waters is carried to western Europe by the prevailing winds, and contributes to soften the climate there. These currents are ever active, and contrast strongly with the disturbed waters through which they pass. Guided by some irresistible power, they pursue their course through the agitated element which surrounds them, unmindful of the storms that impede their progress, but cannot defeat their end.

By retracing our steps, we find that the various zones of the astronomical climate are caused by the elliptical figure of the earth, by reason of

which the surface is unequally exposed to the solar rays, other elements of course contributing to the result; and that the isothermal, isocheminal and isotheral lines, would be uniformly parallel to each other over the whole terrestrial surface, were it not for the division, distribution, and contour, of the continents, their mountains or reliefs, and the unequal absorbing and radiating powers of the surface. But as the beauty and fertility of large sections of the globe depend on the special provisions for the advantages which their location otherwise would have denied them, we find they have been provided in the arrangement and adaptations of the fluid and solid portions of the earth. The grand object contemplated by the INFINITE MIND is stamped indelibly on every part of the universe, and all the particles, however affected by the laws of matter, contribute to the final result. If a plateau is necessary to water the valley, it rises at the bidding of the ETERNAL. If the geographical form and position of a continent require a mountain chain to condense the passing vapor, it rises also at the same ALMIGHTY bidding. If a gulf is needed to modify the climate of a continent, and counteract the influence of the terrestrial reliefs, the hills are rolled back and the gulf appears. Can it be said that all these local and important agents, acting so harmoniously with the mysterious

forces that pervade the universe, are the offspring of chance? That the terrestrial reliefs, acting so variously on the local climates, on which so much of life and beauty depend, are the accidental results of indeterminate internal powers?

The mind is not so much affected by the grandeur of any single phenomenon, however important, as it is by the harmonious action of different and apparently conflicting elements. It is this intimate and indispensable relation which exists between the greatest and the smallest of created beings,—between the animate and inanimate worlds; this action and reaction upon each other, by which the end is accomplished; and the special provisions, modifying or wholly defeating the action of general laws, where the interests of our species require it, that tend most strongly to direct the inquiring mind upward to the INFINITE and ETERNAL, for a revelation of the hidden cause.

But if we look at the general result of the division of the earth's surface into zones of temperature, we will find a most favorable condition. The torrid zone stretches from the equator to the tropics, embracing an area of seventy-seven millions seven hundred thousand square miles. The temperate zones, extending from the tropics to the polar circles, embrace fifty millions square miles in each hemisphere, making

together one hundred millions. This area embraces at least three fourths of the continental element. The polar or frozen zones contain only eight millions square miles each; and even this small and unfavored circle is inhabitable. Owing to the compensations in Sweden, the *cereals* are cultivated beyond the polar circle. Less, therefore, than one eleventh part of the earth's surface is beyond the vivifying influence of the solar rays. And we have seen how small a portion of the continental mass is exposed to the vertical rays of the sun when at its highest point, and how that portion is partially protected by the interposing mists and clouds, caused by a rapid evaporation; by the isolated mountain peaks, from which the cold air rushes down; the general elevation, and the luxuriant vegetation, which keeps the atmosphere more humid, and cools the surface of the earth by its moisture and shade.

Such is the general result of the terrestrial divisions, modified by atmospheric laws and continental reliefs. But by what power were these divisions and arrangements made, if not by an intelligent CREATOR. We have seen that the continental arrangement into pairs, and these again into particular forms, marked by similar curves and relieved by elevated plateaux and mountain chains; by gulfs and inland seas, are indispensably necessary to the existence of the varied

life which abounds on our planet, and that all these elements are adapted to each other; and last, and perhaps not least important, are also adapted to the astronomical and local climates in which they are found. The question of Power naturally presents itself; what authoritative power presided over the internal forces of the earth, when the dry lands were forced up out of the surrounding sea, to their present position? There is no physical law by which they can be explained. No natural cause for the particular division and arrangement of the continental element, to be found in the wide range of human knowledge. For aught we know, or aught that appears to man, the continents might have been gathered around the poles, or collected under the equator. They might have been thrown up in one solid mass; or scattered over the surface of the ocean, in small and insignificant islands. The great mountain chains might have been forced up in the north temperate zones, and the equatorial regions sunk down to the level of the ocean. Yet any of these conditions would have changed the relations of the continental masses, and more or less affected the entire climate, as well as the vegetable and animal life of the globe. Not a single change could now be made without planting the seeds of disease and death in some portion of animate creation.

This great controlling power appears to have acted uniformly and intelligibly in every instance. The local reliefs are thrown up only where they are required to fit the territory or continent for the great ends contemplated. The astronomical climate is modified, wherever a modification secures some important object, and there only. The elements and atmospheric laws depend upon the division and arrangement of the fluids and solids of our globe; yet they act in harmony with each other, however widely separated they may be. Through the laws of expansion and contraction, of heat and cold, the sea cools the climate of the torrid zone, and warms it in the cold, temperate, and frigid zones; and according to these laws, the continents have been arranged. The continents are narrow and greatly elevated in the equatorial regions; and low and divided, with deep bays and inland seas in the higher latitudes. The various climates of the earth, on which the great variety of vegetable and animal life depends, result from the concurrent action of these natural agents. All are important, and all are intimately connected with the division, distribution, contours, and reliefs of the continents. One irregular or convulsive movement of the mighty, upheaving, internal power, by which it is supposed the terrestrial reliefs and continental elevations have been produced, would unsettle

the physical relations which exist, and more or less disturb the harmonious action of the varied forces of nature. Thus, the very confusion and irregularity of the continental masses, scattered apparently without any object over the surface of our planet, may be resolved into an intelligible narrative of their own creation.

III.

THE ATMOSPHERE.

We have repeatedly alluded to the atmosphere, but we have nowhere given it the consideration to which it is entitled in a work of this character. It is, as we have seen, intimately connected with the most important telluric phenomena. Out of it the carbon, indispensable to the vegetable kingdom, is elaborated, and from it animals, by the operation of their lungs, abstract the oxygen, by which their blood is purified. And in this, as in everything else, there is a mutual exchange between the two kingdoms. There is a constant exchange of gases going on between them; but the solar light is necessary to effect the exchange. A full exchange could not be effected without it. Plants cease their labor at night, and may be said to sleep as well as animals; at this time

no exchange can take place, for the action of vegetables is not sufficient to throw off the gas required by animals. The solar light, therefore, is a necessary element in this exchange. But there are exceptions in the vegetable kingdom; some plants are most active during the night, choosing its silence and gloom for the opening of their flowers, and sending up their fragrance rather to the midnight stars, than to the noonday busy world of sentient beings.

The atmosphere is the medium through which sound is transmitted, and on its reflective and dispersive properties the solar light depends. Without it, objects could be seen only in the direct rays. "Every shadow of a passing cloud would be pitchy darkness; the stars would be visible all day, and every apartment into which the sun had not direct admission would be involved in nocturnal obscurity." These powers of the atmosphere are increased by the action of the solar rays, which produce an irregularity in the temperature of the different masses of air. Thus, the atmosphere is necessary to diffuse the solar light in an agreeable manner, and to mitigate its intensity. Without it we should have nothing but the glare of intense sunshine, or the most impenetrable darkness. It is not only necessary in these important offices, but also to the more exalted faculties of man. Supposing we could live in its absence,

which is impossible, we should possess our organs of speech and hearing in vain, no matter how perfect they might be. "Voice we might have, but no word could we utter; listeners we might be, but no sound could we hear. The earth would present itself to our imaginations as a soundless desert."

It retains and diffuses heat, whether from the sun above or from internal sources. By these means, the temperature of the seasons is regulated, and the seas kept liquid. In this, however, its pressure is an important element. Were it not for the atmospheric pressure, our globe would be surrounded with a thick vapor. This pressure is necessary also to all organized bodies composed of solids and fluids. At great heights, where it is less, difficulties are always experienced by the adventurous traveller. Nearly all the young Americans who attempted to ascend Popocatepetl, which has an elevation of seventeen thousand seven hundred and twenty feet above the sea, were compelled to return long before they reached the highest point. They experienced great difficulty in breathing, and in a few instances the blood oozed out of their lips. This resulted from the want of atmospheric pressure, which at that great height was not sufficient to regulate the elasticity or expansive power of the fluid portion of the body. The atmospheric pressure is so small, says Humboldt, in his

Aspects of Nature, at an elevation of thirteen thousand four hundred and twenty-three feet, on the plateau of Antisana, that the cattle, when hunted with dogs, bleed from the nose and mouth. Herr Von Tschudi, referred to by Humboldt in the work just mentioned, thinks the death of the dogs and cats, in the elevated town of Cerro de Pasco, is the consequence of the absence of sufficient atmospheric pressure. "Innumerable attempts have been made to keep cats in this town, which is fourteen thousand and one hundred feet above the level of the sea, but such attempts have always failed; both cats and dogs die at the end of a few days, in fits. The cats are taken at first with convulsive movements, when they try to climb, but soon fall back, exhausted and motionless, and die."

The atmospheric pressure is necessary also to the vegetable kingdom. Plants depend on the atmosphere, as well as animals; and are therefore provided with porous openings in their leaves. They have a kind of respiratory system connected with their external and internal coverings, which is quite as important to them in the evaporation, inhalation, and exhalation of their fluids, as these functions are to animals; for the elasticity of their fluids depends as much upon the atmospheric pressure as that of animal fluids. It is owing to this fact, that the Alpine

plants are adapted, by their more abundant pores, to their elevated position, and cannot be successfully cultivated in the low grounds. The increased pressure disturbs these vital functions, and, sooner or later, destroys their action. This pressure, then, is as essential to life as the gases on which it depends. In the physical, as well as in our moral nature, certain restraints are necessary. When the first are removed, or, when we are placed above the restraining pressure, the fluids of the body burst the delicate vessels, which are no longer able to restrain their elasticity; and also, when the "interior power gives up its authority, the animal and the sensual take the place of the human and the spiritual."

The tops of our highest mountains are covered prepetually with snow; thus proving the fact, that the solar rays would not be sufficient without the aid of the atmosphere, to prevent a universal destruction of life. Without the atmosphere, the earth would be as barren and lifeless as the moon appears to be; yet it is not essential to any of the great mechanical functions of our planet in the economy of the solar system. The earth would perform its regular revolutions, maintain its axis, and discharge all its various offices in the system of which it is a member, without this envelope, but it would be an arid waste; volcanoes it might have, but no cities for destruction;

mountains and valleys might diversify its surface, but they would be unenlivened by the murmur of streams, or the music of animate nature. If there were no physical necessity for it, these facts most clearly show that it must have been designed to perform the important offices to which we have alluded. The atmosphere is also important in connecting remote climates, and effecting mutual exchanges between them, by which their extremes are greatly modified.

This important appendage or envelope is dependent on a thousand agents for its elementary parts. Each thing acts upon everything else, and all are bound together by relations and dependencies which pervade the universe. Volcanoes and warm springs; decomposing rocks, and decaying vegetable and animal matter; the respiration of animals and the combustion of the various articles of fuel, keep up the supply of carbon, so important to the vegetable kingdom; while the respiration of plants and various other natural agents, maintain the proportion of oxygen, upon which animal life depends. The alkalies are found in all felspathic and other rocks of igneous origin; from which they are disengaged by the action of the atmosphere and water. Had they been deposited in the earth, or in any easily soluble form, they would have been washed away in a short time.

But, deposited as they are, the action of the elements is just sufficient to keep up the necessary supply.

In the new edition of Professor Daubeny's Work on Volcanoes, recently published, he says: "Potash, soda, certain earthy phosphates, lime and magnesia, must be present wherever a healthy vegetation proceeds. Now, some of these bodies are naturally insoluble in water, while others are dissolved with such readiness, that any conceivable supply of them, in their isolated condition, would be speedily carried off and find its way into the ocean. The first, therefore, must be rendered more soluble, the latter less so, than they are by themselves. Now, the manner in which nature has availed herself of the instrumentality of volcanoes to effect both these opposite purposes, is equally beautiful and simple. She has, in the first place, brought to the surface, in the form of lava and trachyte, vast masses of matter containing the alkalies, lime and magnesia, in what I have termed a *dormant* condition; that is, so united by the force of cohesion and of chemical affinity as not to be readily disengaged and carried off by the water. . . . She has also provided, in the carbonic acid, which is so copiously evolved from volcanoes, and which consequently impregnates the springs, in these very countries, more particularly where volcanic products are found, an agent capable, as completely as muriatic

acid, though more slowly, of acting upon these rocks, of separating the alkalies and alkaline earths, and of presenting them to the vessels of plants in a condition in which they can be assimilated. Thus every volcanic as well as every granitic rock contains a storehouse of alkali for the future exigencies of the vegetable world; while the former is also charged with those principles which are often wanting in granite, but which are no less essential to many plants. I mean lime and magnesia. Had the alkalies been present in the ground in beds or isolated masses, they would have been speedily washed away, and the vegetables that require them would by this time have been restricted to the immediate vicinity of the ocean." But, notwithstanding this beautiful provision, large quantities of the alkalies and phosphates are annually carried into the ocean, where they are held in solution. These are collected, by another arrangement, which though more humble in its character, is not less beautiful. It is done through the agency of the *algæ*, or sea-weeds, which occupy the lowest place in the vegetable kingdom; but yet, are used in an important office in the economy of nature. These weeds are seen clinging to the rocks, or floating along the coasts, as idle vagrants of the deep, but they are not idle, or useless. The alkalies and phosphates held in solution by the salt water, are collected

by them and deposited on the coasts, where they become useful, and, in many places, as in the north of Scotland, indispensably necessary. By the manure supplied by the decaying algæ the peaty and waste soils are made productive, and potatoes are raised in large quantities, where without it nothing could be produced. It is, indeed, a strange and melancholy sight, to see the thousands of poor people hurrying and driving along the coast at low tide, contending for these tangled weeds, upon which their very existence depends, with the fierceness of petty politicians, and not unfrequently their meanness.

The algæ are most beautifully adapted to the office they perform. Other vegetables are stationary, and derive their nourishment from the soil in which they are rooted and the atmosphere surrounding them; but the algæ have no roots. They have simple processes, or hooks only, with which they cling to the rocks. They derive their nourishment from the alkalies and phosphates held in solution in the salt water; and not from the soil, for with this they have no connection. The plant is kept up, and the branches and leaves expanded by means of air-bags, which are peculiar to this family. By these air-bags the specific gravity of the plant is lessened; and thus, it is kept floating around the ocean, and brought in contact with the alkalies and phosphates which it collects.

Turning again to the subject of volcanoes; we find that they also supply nitrogen and carbon; the first in ammonia, and the last in carbonic acid. By this carbonic acid the rocks are decomposed and their fertilizing materials liberated; it also produces new limestone rocks, which compensate for those converted into silicates by volcanic heat in the interior, and aids in purifying the atmosphere, through its decomposition, by the respiration of plants. It is thus that these mighty agents of destruction, which seem the real antagonists of life, are in fact the appointed means for supplying the materials out of which all organized bodies are fashioned. Warm and mineral springs also contribute to the proportion of the gases, without which life could not continue. These various agents are connected with the interior of our globe; and as they supply the gases which nature is most constantly demanding, it may be inferred that the earth contains within itself a sufficiency for all future periods. These gases have an intimate connection with animal and vegetable life, and depend in some degree on the relative proportion of the two kingdoms. Their unequal distribution is corrected by the circulation of the winds; by which the excess of oxygen is carried from the tropical regions to the higher latitudes, and the surplus carbonic acid is conveyed from the higher latitudes to the tropical forests.

Thus throughout the whole universe, we find an uninterrupted chain of relations and dependencies. We live not for ourselves, but for every one—for everything else. There is no independence in the economy of GOD;—all are ministers of HIS manifold designs, and fellow-laborers in accomplishing the objects for which they were created. Between the office performed by the algæ and the necessities of man there exists, as we have seen, an important and highly interesting relation. Not less so is that which we maintain with the worm beneath our feet. The one gathers up the materials which are scattered through the vast ocean, and deposits them on the shore, where they fertilize and enrich the soil; while the other purifies that soil by extracting all injurious substances. And all this is done for man, for whom everything seems to have been created. To supply his wants and gratify his desires, a teeming world empties its rich profusion at his feet. To soften and ennoble his character, the music of a thousand spheres exhausts its melody.

"If the heart, too confidently raised,
Perchance too lightly occupied, or lulled
Too easily, despise or overlook
The vassalage that binds her to the earth,
Her sad dependence upon time, and all
The trepidations of mortality,

What place so destitute and void—but there
The little flower her vanity shall check—
The trailing worm reprove her thoughtless pride ?"

All the natural laws, whether connected with the force of attraction, the size, axis, and revolution of the earth; the proportion of land and water; mountain and valley; the composition of the earth, or the atmosphere that surrounds it; or of heat and cold, more or less affect the physical, intellectual, and moral character of man. This intimate relation, this brotherhood of agencies, imposes certain restraints upon each one, and corresponding penalties for their violation. In our simplest exertions a hundred laws are involved, like so many wheels in a machine, and the most perfect harmony in their action is essential to success. If it were not for the laws of gravitation and repulsion we could not walk, yet these depend on the relative magnitude of the earth and our bodies. The depth of the atmosphere determines the condition of our fluids, and the resistance of our blood-vessels; while our respiration and exhalation are regulated by its weight, moisture and temperature.

There is one more general law to which we desire to call attention; we allude to that by which the expansive power of all fluids, and most of the solid bodies of our globe, is regulated. Heated atmosphere rises as water does, when the latter is converted

into steam. By this law we are relieved from the carbonic acid gas thrown off in respiration, which would prove injurious if re-inhaled. It is heated, and therefore lighter, and as soon as it is respired or thrown off, it rises in obedience to this law, while a purer atmosphere is forced down by its weight, to be inhaled. If it were not for this law, and others which contribute to produce the constant action which is going on in the atmosphere, serious difficulties might take place from the respiration of a stagnant and poisonous air. To this law, we are also indebted for our rains, with the innumerable blessings which they secure. But there are limits to this, as there are to all natural laws; and in this case, the limitation is as important as the law itself. Water is evaporated by heat, and the vapor ascends; hence the phenomena of clouds; it is also condensed by cold, hence our rains and snow; but it is condensed by cold to a certain point only, after which it is expanded. It has been ascertained by experiment that forty degrees is the mean point, and that water expands when above or below that degree.

The necessity of these laws is most striking, and the result of their action, a most convincing evidence, not only of the prescience, but of the wisdom and goodness of the great Creating Power. If ice were heavier than water, it would sink as fast as formed on

the surface, and unless it was thawed as rapidly as it was formed, the sinking layers would soon fill up our lakes and rivers with solid bodies of ice. This, it is almost unnecessary to add, would soon destroy all animate matter in them. It is therefore as important that water should expand when frozen, as it is that vapor and heated atmosphere should rise. If the vapor did not rise we would have no rain or snow,—no springs and rivers, and as a consequence, no vegetation. If water did not expand when frozen, we would have no lakes and rivers, though we might have rains and snows; it is true they might exist for a short season, but for all the great purposes of life they would fail. Thus we see the importance of this general law, and the no less important limit to its action, by the specially adapted law of expansion in the case of ice.

Thus far we have grouped together, in one general view, a few of the most interesting phenomena: showing or attempting to show the relation they sustain to each other, and how the phenomenon of life itself depends on the continued and harmonious action of the multiplied physical forces, which keeps the various parts of the vast machinery in motion. In this view many of the most mysterious agents have not been referred to, because their connection and nature could not be explained in a work of this cha-

racter. We have not noticed that mighty net-work of electricity and magnetism which constitutes the nervous system of our planet; an invisible and irresistible agent which pervades all nature; "which circulates through all the organs of plants and animals, and acting on the nerves, promotes the circulation of the organic juices; which flashes from the thunder cloud; illumines the wide canopy; draws iron to iron and directs the silent recurring march of the guiding needle;" lights the north with the changing and varied colors of the aurora; keeps the different particles of the earth's surface in an unceasing action by the exchange of properties; "sustains a manifest relation to all phenomena of the distribution of heat, of the pressure of the atmosphere, and its disturbances;" which is now the defence of the South American eel, and now the fearful presiding spirit of the approaching storm. We know, however, that the agency of this mysterious element is important and indispensable; and that it also must have been adapted to, and created for, the performance of these various offices in the system.

Truly, all the elements and laws in nature, sustain an intimate relation to each other; all have appropriate duties to perform; and it is doubtful whether the action of the least and apparently the most useless agent in the vast domain of God, can be dispensed

with. The venomous insect beneath our feet, and the noblest and best of our domestic animals; the terrible forces of the earth, the tornado and volcano; the gently murmuring spring, and the boisterous ocean; the forest monarch and the pale forget-me-not within its shade, are all witnesses of creative POWER, and ministers of good. Man, to whom the distinguishing characteristics of reason and free-will have been given, is the only unfaithful servant. Everything else performs a part, and performs it well. He only fails to perform the high mission to which he has been appointed by the great CREATOR. The grand forces of nature have been committed to his care. To him, the sea has been given as a pathway for commercial intercourse; and the elements made obedient to his will. At his touch the heavens are kindled with electric fire; and then, again, the same fierce element is sent a quiet messenger to do his bidding. But these powers have been given to him for the noblest purposes and best interests of his species; that he may best relieve the poor, comfort the sorrowing, aid the distressed, teach the ignorant, and reform the vicious. And thus, although his endowments are incalculably great, they are not more than commensurate with his important duties. They are, however, sufficient for all the purposes of life; and if properly observed and wrought, they

will brighten his pathway as he approaches the confines of this, and safely light him into the far-off silent land whither he goes,

> "Into the silent land!
> To you, ye boundless regions
> Of all perfection! Tender morning visions
> Of beauteous souls! The future's pledge and band
> Who in life's battle firm doth stand
> Shall bear hope's tender blossoms
> Into the silent land!"

In these remarks on the PHYSICAL GEOGRAPHY of our planet, we have repeatedly referred the existence of phenomena to an invisible but all-powerful cause, without and above the various physical agents which we have noticed. The division and distribution of the continental and oceanic elements; the analogous forms and arrangements of the continents and their reliefs; the harmonious action of the multiplied forces and agents of nature; the importance of the atmosphere, and the laws which make it the medium of exchange between the solid and fluid parts of our planet, and the local and highly important compensations by which the tendency of general laws is limited or controlled, cannot be explained by any proximate cause. The importance of these arrangements and the adaptation of the different agents to

each other, and the harmony of the ever-acting and reacting forces, which constitute the life of our planet, point us to some ulterior cause for the explanation we seek. If the existing continental forms were less intimately connected with the laws by which the other elements are controlled, and less essential in the economy of life, the evidence of original design which they furnish would fail to convince the mind, however analogous they might be in themselves. Certain analogies might exist between continents thrown up to their position by the same indeterminate force; but that these analogies should exist just where they are required, and that contrasts should be found wherever location or climate makes them essential, could not be expected without the agency of some designing intelligence. If a single note of discord could be heard, or an irregular movement detected in the vast domain of nature, then in some degree would we be excusable for seeking the primary cause of all these forces and forms, in a power less perfect than the Omnipotent and Omnipresent Creator. But we are not thus left to grope our way through discordant and conflicting elements; there are no exceptions to these general laws, which are not as important as the laws themselves; no discords in the great song of creation, all is grand, and full, and harmonious. The "sensitive and reverent ear"

of nature's votary, is ever cheered with the perpetual music of her countless encouraging voices.

The unequally woven carpet of flowers and plants with which the earth is covered as with a garment, minister alike to the wants of animal life, and the exquisite sensibilities of the refined and intellectual; while every department and recess of nature teems with animal existence, which is equally important, and infinitely more interesting. Far down in the bowels of the earth, where light can scarcely penetrate, and high above the region of perpetual snow, the chosen abode of the giant condor, the almost ceaseless hum of busy life may be heard, and its various changes distinctly traced. From the little animalcula with its existence of a moment, up through the multiplied grades and forms of life, to the intellectual sovereign, whose spiritual part, at least, is inseparably interwoven with things eternal.

Each step we take in this mighty temple of varied organisms, at the head of which, and as the crowning piece, man, the noblest of created beings, has been placed, suggests new inquiries, which, unanswered, turn back upon the startled imagination, arousing the dormant faculties of the soul to contemplations of a higher order. But these things only invite the faltering footsteps onward in the vast field of inquiry. However much there may be to startle the timid, and

discourage the indolent, there is nothing which is calculated to cool the ardor or limit the desire of the anxious student; although the point to which he vainly aspires is constantly receding before him. "The strain of music from the lyre of science flows on, rich and sweet, full and harmonious, but never reaches a close; no cadence is heard with which the intellectual ear can feel satisfied. . . . The idea of some closing strain seems to lurk among our own thoughts, waiting to be articulated in the notes which flow from the knowledge of external nature. The idea of something ultimate in our philosophical researches, something in which the mind can acquiesce, and which will leave us no further questions to ask of *whence*, and *why*, and by what *power*, seems as if it belonged to us; as if we could not have it withheld from us by any imperfection or incompleteness in the actual performance of science. What is the meaning of this conviction? What is the reality thus anticipated? Whither does the development of this idea conduct us?"

This conviction is one of the highest to which we can attain, and seems to belong to that part of us which reaches out into the unknown future whither it conduct us, and the reality of which it dimly reflects, as light from behind the distant hill-tops, into the valley of life. Of these deeply interesting matters,

much is already known from the phenomena which we have described; but the most interesting and perhaps the most important questions are yet unanswered; many of which will not, cannot be known to finite beings. Beyond the horizon that binds our vision, and there only, will such questions be satisfactorily answered. Thither with anxious eyes and trembling steps; with deeper interest and increasing humility and reverence, let us advance. There surely, if not before, these mysterious questions will be explained, and a more perfect revelation of the glories which are seen now through an obscured and imperfect vision only, will be made when the material veil is removed from the grand, still mirror of eternity.

CONCLUSION.

In the arrangement of the phenomena to which we have referred, we have endeavored to show the connection which exists between them, and their mutual dependence on each other; as well as the harmony which appears through, and in, every part of the vast machinery. Each part is linked with and bound to every other part; and the mighty whole depends alike upon the greatest and the least of its constituent elements. The falling feather attracts the earth in proportion to its weight, and the sound of a single word may vibrate through the universe.

This well-ordered connection and consequent harmony between the various physical agents, and the general adaptation of animate and inanimate, of vegetable and animal matter, clearly prove the action of an Intelligent Creator, who not only foreknew the necessity of each part, but created that necessity, and established the laws by which the action of each

member is to be directed and controlled. There was no accident in all this—no fortuitous beginning, either of animate or inanimate matter, and therefore there can be no fortuitous ending. The same INFINITE HAND stays the tides, and binds the oceans to their beds—directs each distant orb in all its movements, and holds the varied systems in harmony together.

The planets were destined to pursue certain fixed pathways in the fields of space, and therefore, if deflected by some collateral power, that power is counteracted by some other potency, by which the wandering planet is swung back into its appointed orbit. If the earth is drawn into a dangerous proximity to the sun during its revolution, the heat of that body is avoided by the inclination of the earth's axis, and by the law of gravity, which increases its motion as it approaches the great central luminary of our system.

Without some compensation, the equatorial parts of the earth's surface would be barren and uninhabitable wastes; but they are redeemed from this condition by the arrangement of the continental and oceanic elements, the atmospheric laws, and their own elevation,—conditions which we have seen are indispensable to the present character of our climates. The solar rays might distil vapor out of the ocean, and the winds might bear it over the continents; but,

without the present constitution of the atmosphere, by which it is lighter and colder in the upper strata, and the elevation of mountains and mountain-chains, by which it is forced up into the colder regions, where it is condensed into rain, and then precipitated upon the continental element, the grand ends effected by it, and for which it was ordained, would not be accomplished. Thus our rains, which appear so simple and natural, are the result of many concurring phenomena, and depend upon the constitution of the atmosphere, and the oceanic element, the influence of the solar rays, and the irregular elevation of the earth's surface.

But this inclination of the earth's axis—this arrangement of the two elements under the equator, and the elevation of the continental part—and these mountains and mountain-chains, are wholly arbitrary. There is no necessity in their own organization for the conditions which they observe. They might have been different, from any natural law known to man. Nor is there any physical cause for the particular formation of the continents, or their arrangement in pairs, or their elevation as they approach the south; yet we have seen that these conditions are important, if not indispensable in the economy of our globe. Gravitation explains the varied movements—the revolutions and inclinations of the planetary bodies,

and secures the stability of the system; but there is nothing of that kind to act upon or control innumerable important agencies more immediately connected with the development of animate matter on the planet we inhabit.

The atmosphere is adapted to the diffusion of light and heat, and on its action all living beings depend; while the laws connected with it, keep the aerial envelope of our globe in a constant motion, by which many beautiful and necessary compensations are secured to local climates. Yet, there is no necessity for this envelope in any of the motions of our globe, or in any of the relations it sustains in the solar system; nor has the searching eye of science been able to detect its origin or cause. It is also connected with the various changes of the earth's surface. By it the vapors which supply the running streams with water are carried from the oceans to the interior, and through them many of the changes on the earth's surface are effected. It also contains the elements out of which all vegetables are fashioned, and thus supplies the means for restoring the wasted soil. In this way, the waste of the external elements is compensated by the internal agencies, and the demands of the organisms without are supplied from the unfathomable depths within.

We have seen how the solar light acts upon the

vegetable kingdom, and how its different rays are adapted to their seasons of growth and maturity. And also, how the division and arrangement of the continental mass harmonize with the atmospheric laws, and how the action and reäction of the two elements contribute to that necessary balance, in which not only the prosperity, but the happiness of man is involved. Without any further enumeration of these special adaptations, it must appear to all, that each agent in nature is connected more or less intimately with every other agent; and that the present relation and condition of things depend on the concurrent action of all. Nothing is wanting, nor can anything be dispensed with. There is no confusion or antagonism to be found among these various agents and elements. Harmony is the law by which they are governed, and universal good the object of all their actions.

These limitations and balances are not confined to the physical forces alone. They extend through the vegetable and animal kingdoms also. Vegetables limit the growth of each other, and animals restrain the growth of the entire kingdom. But if insects and animals were not limited by the destroying propensities of each other, the vegetable kingdom would be swept away in a season. Every plant has its particular insect, which preys upon it,

and thus retards its growth and limits its multiplication. Grasses have their *phalæna graminis* to check their growth. The fir-cone has its *phalæna strobilella*, which would prove ruinous to the whole species, were it not for the cunning *ichnumon strobilella*, which destroys them by depositing its eggs in the young caterpillar, with its long tail. Animals also feed upon each other, by which means a dangerous increase is avoided; and the insect creation is kept within the limits of safety. Were they permitted to increase for a single season without restraint, the whole earth would fall before the insect army. By laying the earth waste, and leaving it barren and uninhabitable, they would prove themselves mightier than Xerxes with all his armed men; and more successful in destroying than Alexander or Napoleon! The busy fly, which appears so useless in its constant activity, is all the time performing some important mission; and insects which are unable to do any positive good, prevent others from doing injury.*

This mighty mechanism of innumerable parts could not be sustained for a single moment, without the supervision of the presiding INTELLIGENCE which resolved its plan and adapted its various members to each other. Influences and laws may exist, and existing by the appointment of the supreme ARCHITECT, they may perform the offices for which they were originally

* See Appendix—Note A.

designed, but they are means only in the hands of the Infinite Creator; and as such, they require His constant supervision. He who created all things seems to have reserved to himself an invisible part of each separate creation. The smallest and the greatest contain something which cannot be comprehended by man. There is a limit to all human knowledge, beyond which all is involved in mystery. This is true of all parts, whether distant from us or near to us. The distant stars, so remote that it requires centuries for their light to travel to our planet, are almost as well understood as the sphere we inhabit. The planets have been measured, and their weight determined; and the geography of the moon has been written out with as much accuracy as that of any of our continents. The invisible power which binds the innumerable systems together as one mighty family and forces them into reciprocal action, has been detected, and made the key to explain the mysterious movements of the heavenly bodies. The winds have been interrogated, and their origin, object, and destiny ascertained; and the invisible electric agent has been reduced to servitude, and made the means of communicating thought over vast territories and to distant lands. The physical forms of organised beings have been traced into their minutest parts, and followed down to their earliest stages; and their resem-

blances and distinctions fully registered. But we find, great as these achievements are, and worthy too of the distinction which man so proudly bears above the creation around him, that they are limited. In each case there is something beyond the reach of human intelligence. The dim outlines of knowledge have been gradually extended by the labors of the few great minds, which have successively marked the epochs of learning and science; but there is a depth of mystery without that circle, which they have not been able to fathom.

Enough, however, has been made known to man, through the grandeur of the natural agencies, and their harmonious and beneficial action, to inspire a faith in the infinite power and goodness of the GREAT CREATOR. Against these manifestations, the atheist has exhausted his energy without effecting a single breach in the battlements. Each stroke of his hammer brought out the fire of some latent truth; and every step he advanced into the unexplored territory, introduced him to additional witnesses. This revolving planet, moving on its pathway with a remarkable and fearful rapidity, and the distant planets, beaming down upon us with their bright and cheerful faces, and the mysterious potencies which work out the behests of the CREATOR, all seem, in their silent grandeur, to mock at his presumption. The lightnings of heaven

reprimand him, while the ocean thunders back his falsehood.

The apparent contradictions between the Mosaic Cosmogony and the natural record, resulted, as we have seen, from imperfect data, and hasty generalizations. As soon as genius succeeded in arming the astronomer with instruments of greater space-penetrating power, and time and labor had more perfectly unfolded the fossil records of the earth, the contradictions disappeared. The true philosopher was then enabled to show the intimate relation between every part of nature's varied elements, and their perfect agreement with the inspired history. Then, and not until that time, were the sons of science able to indicate the true pathway, and point the traveller up through the clouds and darkness of preceding errors, to the great SOURCE of all life and all beauty.

Truths barely alluded to in the sacred pages, have been demonstrated by science. We are taught in the inspired history, that the ALMIGHTY CREATOR caused the waters under the heaven to be gathered together unto one place, and made the dry land appear; and geology also teaches us that there was a time when the waters covered portions of the earth which are now dry, and that changes have been effected by the spirit moving over the face of the waters. We are taught also, that at the Divine

Mandate the earth brought forth grass and herbs yielding seed, and fruit trees yielding fruit after their kind. And that GOD saw that all these were good, and then set up the firmament of the heavens with lights to rule the day and the night; and made the signs for the seasons, and for days and years. That after the fourth period of time, HE bid the waters bring forth abundantly the moving creatures that have life, and fowls to fly above the earth in the open firmament of heaven. It is written that God then created whales and other living creatures which the waters brought forth. The fifth grand epoch was then closed; and the sixth commenced with the creation of cattle, and the creeping things and beasts of the earth, which were made after their kind, and were good in the sight of their Creator. After these God created man in His own image, to whom He gave the dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and every creeping thing that creepeth upon the earth. And He blessed male and female, and bid them be fruitful and multiply, and replenish the earth, and subdue it, and have dominion over all things. These are the successive steps in the creation, attested not only by the word of revelation, but by nature's widespread record.

To man, the GREAT CREATOR gave the dominion of

all things; and we find him gradually asserting his power. The existence of the electric fluid was known to the sacred writers. They spoke of it as pervading all space and all bodies, and as kindling the heavens with fire, by which the ALMIGHTY traced his pathway in the thunder, and regulated the course of the tempests. It is but recently, however, that man has asserted his control over this element, and made it do his bidding. Solomon said, "that God gave to the air its weight, and to the waters their just measure;" yet it was not until recently that science proved the air to be a ponderable body, and learned the just measure of the waters. Job first announced the existence of a central fire in the earth; and science proves it by the natural phenomena discovered.

When Herschel said, "that all human discoveries seem to be made only for the purpose of confirming more strongly the truths contained in the sacred writings," he fully recognized the relation which exists between the truths of revelation and the discoveries of science. What was then uttered by a bold mind with timidity, is now known to every intelligent reader. The book of revelation and the book of nature, were written by the same Infinite and Unerring Hand; and each day adds some new proof of their Divine origin. As science interprets the sacred

record, its truths are better understood, and their influence more deeply felt. The two voices; the one from above, the other from beneath and around us, seem to unite; but, notwithstanding all space and all matter are full of their eloquence, man has been slow to understand their language, and reluctant to acknowledge the truths which they unitedly teach.

From the worm of the dust, the simple flower of the field, and the timid songster of the forest, to the globe we inhabit, and up through the innumerable worlds that shine above our heads, reflecting the image of each other in the grand, still mirror of infinity, traces of the same all-pervading, eternal wisdom are seen. Man himself, more mysterious than all else—grander than the star-bespangled firmament—highest of all created matter; whose eternal part is connected with all ages, and enables him to grasp the whole, and will live in the freshness of its youth when all else shall have passed away; seems to have been the last and the greatest act of creative energy. To him has been given the power to unlock the mysterious recesses of the world and read their secret records—to survey the extent and wonders of the universe, and also to appreciate its varied beauties. And it is these distinguishing characteristics, which finally lead his inquiring mind to the true and only source of all

things—that makes the philosopher, and converts his labors into a ministry of good.

Thus, we have arrived at conclusions directly opposed to those of the advocates of Transmutation and development. It is true, they profess to believe in the existence of an All-wise Deity, but they deny that He exerts any immediate influence in upholding the universe, or in perpetuating the multitudinous parts. These important offices they assign to general Laws, which were stamped upon all things in the beginning. To these laws, they contend, the destiny of matter has been committed. Through their agency all organisms are built up, and also destroyed. They rule and regulate the infinitely complex machinery without the supervision of any Superior Power.

Man, according to this theory, need not hope for any exemption from the established laws,—he need not struggle to improve himself or his species; through a certain stage of existence he must pass, subject to certain rules, and without any sympathy from a merciful Creator, to whom he has been directed to offer his morning and evening orisons. No overruling Providence notes his grovellings in the dust, or smiles with approbation on his nobler aspirations.

To these theorists, the story of the pillar of fire by night and cloud by day, is all a fable; and the his-

tory of Calvary, the offspring of the imagination. They, however, encourage us with the hope that a faith may be drawn from their theory, sufficient to sustain us in all the difficulties and trials of life. But they forget that this faith must be found, if at all, in a theory which denies all the attributes of the SUPERIOR BEING,—that contradicts the eternal truths from which the hopes of life issue, as well as that far-reaching faith that extends beyond the difficulties of this sphere of being, into the bright realities of an infinitely higher and purer one. A theory which denies the parental care of an ever watchful and merciful CREATOR, whose unalterable covenant is written on the firmament, and without whose notice not a hair of the head is permitted to fall,—at whose bidding water burst from the rock, manna fell from heaven, and the sea rolled back her tide, until the devoted host had left their native land, then heaved an ocean on their march below. A theory that denies all accountability, by degrading mankind to the character of advanced reptiles, and regulates morals by law—that destroys every hope held out by the sacred record—that blasts all the fruits of faith, but offers nothing consoling in their stead. Upon what place are we to rest? Where are we to find the elements of a sufficient faith?—where the consolations which are

to keep up the sinking heart?—and where the lessons of warning to the oppressor?

None of these important elements can be found within their theory. They hear no voice to encourage them in the trials of life—have no parental heart to yearn over them, sympathising with them in their sorrow, and comforting them in their distress. Lost 'mid the grandeur of natural phenomena, and trembling before their potencies, these theorists find but little to encourage them in their struggle here, and nothing to support and bless them, when that struggle ceases.

It is more agreeable to our feelings to look up to God as a kind and merciful Creator, who loves, pities, and protects us. This view of the Infinite and the Eternal does furnish a faith sufficient to sustain us in all the difficulties of life—a faith that cannot be annihilated—one which has survived the buffetings of ignorance—the persecutions of malice—the prison, the scaffold—the cross, and the grave; with it we are content, and shall wait the end with patience, and be of good cheer.

NOTE "A" TO PAGE 273.

In illustration of our remarks, we have the pleasure of inserting an extract from the works of Michaelis, to which our attention has been directed by the excellent work of the Rev. Dr. Mathews, on "The Bible and Civil Government."

"In this matter the legislator should take a lesson from the naturalist. Linnæus, whom all will allow to be a perfect master in the science of Natural History, has made the above remark in his dissertation, entitled *Historia Naturalis cui Bono!* and gives two remarkable examples to confirm it; the one in the case of the *Little Crow of Virginia*, extirpated at great expense, on account of its supposed destructive effects, and which the inhabitants would soon gladly have re-introduced at double expense. The account of the circumstance is given in the *Hanover Magazine*, for the year 1767, as follows:—'In the English colonies of North America, it was remarked that a certain sort of crow frequented the pea-fields; and in order to put a stop to its ravages forever, its utter extirpation was resolved on. But this was no sooner effected, than an insect of the beetle kind, which had always been known also to do some mischief to the peas, multiplied to such a degree that very few peas were left. An intelligent naturalist thought this occurrence worth investigating, and that the crows were not in quest of peas, but only devouring these beetles; and, of course, that had they not been extirpated, these insects could not have increased so much, and the crops of peas would have been more abundant. At somewhat less expense the same truth was, sometime since, confirmed in Sweden. The common crow was thought to be too fond of the young roots of grass, being observed sometimes to pick them out and lay them bare. Orders were therefore given to the people to be at all pains to extirpate them, till some person, more judicious, opposed this, and showed that it was not the roots of the grass, but the destructive caterpillars of certain insects which fed on them, that the crows searched for and devoured."

"Every one knows what vexation sparrows occasion to the owners of gardens and corn-fields. In the year 1745, fields were not unfrequently to be seen so completely destroyed, that scarcely the seed remained: and in the gardens which they haunt, they pick the peas when they spring out of the earth, with such avidity, that a crop cannot be raised. Their excessive multiplication, therefore, ought certainly to be prevented; and it is the right and interest of every householder to extirpate them on his property. As the mischief they did, about thirty years ago, was so very great, particularly in Prussia, where the laws take more concern in matters of economy than in other countries, there took place, if I rightly remember, at the instigation of a person whose name was *Kretechmar*, such a violent persecution of the sparrows in Prussia, as if their utter extirpation had been determined on. This persecution was just, but it was carried too far, for Kretechmar was too great an enemy to the sparrows; being, indeed, a good economist, as far as a good head, without study, could make him so, but then quite unacquainted with Natural History. And the effects of his ignorance soon appeared; for caterpillars multiplied to such a pitch, that it was found necessary to put a stop to the persecution of the sparrows."

"It is quite a well-known circumstance, that in the year 1761, after the conclusion of the war, when the sparrows in that corner withdrew far from the city into the fields, because among the great quantity of spilled corn they found superabundance of food, it was impossible to protect the gardens about Gottingen from the depredations of the caterpillar.

In North America another evil has been found to result from destroying too many of these birds. The gnats increased to such a degree, especially in moist places, that the people and the cattle were harrassed by them much more than formerly. These examples serve pretty strongly to show, that, in respect at least to birds, we ought to place as much confidence in the wisdom and kindness of nature, as not rashly to extirpate any species which she has established in a country as a great and, perhaps, indispensable blessing."